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THE ELECTRICIAN:

A WEEKLY JOURNAL OF

THEORETICAL AND APPLIED ELECTRICITY AND CHEMICAL PHYSICS.

VOLUME XVII.

FROM MAY 14 TO NOVEMBER 5, 1886.

REESE LIBRARY OF THE UNIVERSITY OF CALIFORNIA.

LONDON:

Printed and Published for the Proprietors by GEORGE TUCKER, at "THE ELECTRICIAN" Offices, 1, Salisbury-court, Fleet-street, E.C.

1886.

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THE ELECTRICIAN:

A WEEKLY JOURNAL OF

THEORETICAL AND APPLIED ELECTRICITY AND CHEMICAL PHYSICS.

No. 1.—Vol. XVII. FRIDAY, MAY 14, 1886. Price 4d.

NOTES.

Cable Interruption.—The steamship, the "Lady Carmichael," has been sent to repair the fault in the French cable.

The Brazilian Submarine Telegraph Company.—The traffic receipts of this company for the week ended 7th inst. amounted to £2,640.

Telephony in Mexico.—The *Economista Mexicano*, of April 22, announces the concession of a privilege for ten years in favour of Mr. James Harris Rogers, for his system of a telephone service.

Gas and Electricity. — We gather from an American contemporary that the gas companies in Brooklyn, New York, have made application to the State Legislature for power to furnish electric light as well as gas.

Great Northern Telegraph Company.—The final dividend of 6s. per share for 1885 is now payable at the company's bankers, Messrs. C. J. Hambro and Son, 70, Old Broad-street, London, E.C., against Coupon No. 6.

The Telephone in Italy. — The Italian Government is doing everything it can to promote the telephone industry, and has recently authorised the erection of a telephone system connecting three villages in the neighbourhood of Genoa.

The Western and Brazilian Telegraph Company.—The traffic receipts of this company for the week ended 7th inst. were £1,749, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

The Hanover Square School.—The report of the examiners of this school, just received, announces that the following students have obtained full certificates :—Léon Drugman, E. C. Mozzoni, P. S. Tasker, and A. A. Voysey. The chief examiner was Mr. H. R. Kempe, of the G.P.O.

West India and Panama Telegraph Company.—We are informed that at a meeting of the directors held on May 12th it was decided to place £2,000 to reserve, and to recommend to the shareholders at the approaching meeting that a dividend of 6s. per share be declared on account of arrears of dividend on the first preference shares.

Electric Lighting Bills.—The Select Committee of the House of Lords appointed to consider the Electric Lighting Act of 1882 Amendment Bills, of which three are before the House, is now taking evidence. The Committee, however, resolved that evidence should be taken in private, and the public is therefore excluded.

A Curious Patent.—An electric horse unhitcher has been patented by Mr. Andrew J. Coffee, of Portland, Oregon. Combined with an electro-magnet is a lever, with a stem loosely carrying an armature, a spring for pressing the armature upwards, with other novel features for automatically unhitching horses in engines and truck houses on a given signal.

Press Telegrams to Australia.—A Reuter's telegram from Melbourne says :—The Victorian Government has consented to allow those colonies which do not contribute to the cable subsidy the benefit of the proposed reduction of the tariff for press telegrams between England and Australia. It declines, however, to extend the subsidy to twenty years.

Telephone at Liverpool.—In order that the Queen might listen to the play if she so desired, telephones were affixed to the stage of the Court Theatre, Liverpool, and placed in communication with Newsham House, the residence of the Queen during her visit to Liverpool. "Les Cloches de Corneville" was the opera chosen for Tuesday night, and on Wednesday "La Mascotte."

New Book on Electric Lighting.—Mr. A. A. Campbell Swinton, we are informed, has in the press a small book, entitled "The Elementary Principles of Electric Lighting." It treats the mere elements of the subject in the simplest possible language, and is intended as a rudimentary manual for the use of workmen and non-scientific persons unacquainted with electrical phenomena.

The French Tariff.—The *Standard's* Paris correspondent of Wednesday states that the uniform rate for telegraphing in France is five centimes per word. M. Granet, Minister of Posts and Telegraphs, has just decided that from the 1st of June a reduction of fifty per cent. shall be allowed on all despatches addressed to journals in France. When the Chambers re-assemble he will also lay a Bill on the table for reducing the postage now paid for newspapers.

Electricity and Burglars.—At the Old Bailey on Tuesday, Thomas King, a clerk, was convicted of having committed a burglary on the premises of Mr. Henry Mayer, Museum-street. Mr. Brown prosecuted. The prosecutor was aroused by the ringing of an electric bell in his bed room, and on going downstairs he found the prisoner and another man in the passage.—At Bristol we hear of aid being obtained per telephone by a housekeeper who heard "someone" on the premises.

Telephone Commission in Italy.—We learn from the *Bollatino delle Finanze Ferrovie e Industrie*, of May 9, that the Italian Minister of Public Works has just appointed a commission to hold an inquiry into the telephone systems of Italy and other countries, and their relation to other public works, especially the telegraphs, and further, to propose to the Government such legislative measures as they may think most suitable to regulate the concession, construction, and the working of telephones.

Franklin Institute.—The May number of the *Journal* of the Franklin Institute contains a lecture delivered by Mr. C. J. Kintner on "The History of the Electrical Art in the

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United States Patent Office," which puts the electrical work of America into a clear and concise form. The supplement to the *Journal* contains further reports of the examiners at the recent exhibition dealing with the applications of electricity to artistic effects, art production, musical apparatus, and electro-medical apparatus.

SINGAPORE.—We have received some details of the first permanent electric light installation at Singapore. The installation is at the Union Hotel, and has been carried out by Mr. E. J. Wells, whose initiative in the introduction of gas, and more recently of electrical methods of illumination, we have before mentioned. The installation comprises only 11 incandescent lamps, lighting a billiard room and a music hall; but it is said to give great satisfaction. A small 1½ horse-power portable engine drives the dynamo.

NEWSHAM HOUSE.—On the occasion of the Queen's visit to Liverpool, Newsham House was lighted by electric light, sixty incandescent lamps being distributed throughout the royal apartments. The fittings were of a novel character, and arranged to harmonise with the decoration of the various rooms. The electricity was run from storage batteries supplied by the Electrical Power Storage Company. The whole of the work was carried out by the Liverpool Electric Supply Company under the superintendence of Messrs. Holmes and Vaudrey.

OUNDLE.—At the recent festivities given in commemoration of Lord Burleigh's return as member for North Northamptonshire the electric light was effectively used There was no public building in the town large enough for the gathering, and Mr. J. W. Smith placed one of his extensive malting rooms at the disposal of the committee. The motive power to drive the dynamo was obtained from the brewery engines, and between 60 and 70 incandescent lamps were temporarily installed to light the ball room, by Messrs. Storey and Son, electricians, of Oundle.

CLUMBER.—With regard to the note which has appeared in some Sheffield papers, and which we referred to last week, the contractors, Messrs. Blakey, Emmott and Co., reply by the subjoined letter, received from the Duke of Newcastle's representative: — "London, 3rd May, 1886. Gentlemen, — We have received the Duke of Newcastle's instructions to express to you his entire satisfaction with the excellent arrangements made by you for lighting the exterior of Clumber House and the ball room with electricity during the recent festivities. The exhibition seems to have given general satisfaction."

"ELECTRICITY ANALYSED."—This is the title of a small pamphlet by William Boggett, in which he maintains that the formula for water is incorrect, and that besides oxygen and hydrogen it contains electricity. Several of our correspondents have been rather hard upon us for permitting letters to appear treating of electrical matters either in a paradoxical or in an unscientific and ignorant manner. We commend this pamphlet to them if they require to see or to approximately understand not what we give publicity to, but what, more frequently, is safely deposited where neither readers nor critics can be offended by it.

PRESENTATION OF MEDALS TO TELEGRAPHISTS.—On Saturday last at the close of the annual inspection of the Queen's Edinburgh Rifle Brigade in the Queen's Park by Colonel Macpherson, C.B., five telegraphists were presented with medals for serving in Upper Egypt and the Soudan. The names of the men were Andrew Isles, Daniel Thomas, Charles E. Gray (Upper Nile), and Thomas Smith and R. W. Newlands (Suakin). The presentation was made by Mrs. Cunynghame, wife of the Surveyor-General for Scotland. The number of volunteers on the ground was 2,196, under the command of Colonel J. H. A. Macdonald, M.P.

NEW YORK.—The cost of lighting by gas and electricity will be seen from the following figures, giving the prices at which the lighting contracts have been taken for the year:— The contracts for lighting different sections of the city of New York for one year from May 1st next were awarded by the gas commission as follows: United States Illuminating Gas Company 70 cents. per lamp each night; Brush Electric Illuminating Company, 70 cents. per lamp; Consolidated Gas Company, $17.50 per lamp per year; Equitable Gas Light Company, $12 per lamp per year; New York Mutual Gas Company, $17.50 per lamp per year; Central Gaslight Company, $28 per lamp per year; Northern Gaslight Company, $30 per lamp per year; New York and New York Globe Light Company, each $25 per lamp per year.

BURMAH.—The telegraph line, Maulmain to Myawady, has been completed, and it is intended to send up telegraph masters and signallers to open offices on the line. Zimmay, we learn, is the frontier station. The Director-General of Telegraphs has decided to make a separate division of Upper Burmah, the work at present being too much for the supervision of one chief superintendent. A telegraph line is to be constructed over the fifty-seven miles of road between Nandgaon Railway Station and Aurungabad, of which it is said that half the cost is to be defrayed by the Hyderabad Government and half by the Berar revenue. We hear that on his return from Mandalay the Director-General of Telegraphs intends inspecting all the railway telegraph offices on both the Irrawaddy and Sittang lines, and if time permits will also inspect the telegraph offices in the division, along with Mr. Hill, the chief superintendent.

A LARGE DYNAMO.—On Thursday last Messrs. Goolden and Trotter, electrical engineers and manufacturers, Bull Green Works, Halifax, tested a large dynamo destined to go, with another one, to H.M.S. "Severn," and being identical with those supplied by the firm to H.M.S. "Mersey." The dynamo, one of the largest seen in this district, is known as a 26-unit machine. Not having enough boiler power to run their two engines—the factory engine and the testing engine—the firm tried an interesting experiment, running the factory (the machinery of which covers three floors) by diverting about an eighth part of the current through another dynamo which was acting as a motor. The new dynamo was worked by the 40 horse-power testing engine, run at a high speed. It will be driven, when on the "Severn," by a six-cylinder compound engine by Willans, of Thames Ditton. Fourteen machines of this type, but not of the same size, have been supplied by the firm to the Admiralty.

BANK LIGHTING.—The Electrical Power Storage Company has lately added to its list of office installations by the lighting of the new premises of the English Bank of Rio de Janeiro, in Moorgate-street, E.C., by 50 incandescent lamps, distributed throughout the building. Power is supplied by a 4 horse-power new type Otto gas engine, fitted with worm gear for driving side shaft. This is found to be a decided improvement over the bevel gearing, and runs more quietly. The dynamo charges 31 15 L type cells, which are capable of discharging at a rate of 30 amperes for nine hours. In the general offices the lamps are fitted on brass standards, which, together with the shades and holders, have been specially designed to meet the requirements of desk lighting, as they screen the glare of the filament from the eye, and at the same time throw the full light on to the desks. The whole instal-

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lation is being worked by the bank porter, and is giving every satisfaction.

STEAMER LIGHTED BY ELECTRICITY. — The steamer "Gloamin," recently launched from the yard of Messrs. Hall, Russell, and Co., Aberdeen, has now almost completed her outfit. On Monday night the electric lighting apparatus with which she is fitted up was set in operation for the first time by way of experiment. The vessel carries 92 lamps in all, the masthead light and the two side lights displaying a flame of 90 candle-power each, the others being 20 candle-power. The motive power is supplied by a 12 horse-power engine, with a Victoria dynamo apparatus. The principal lights with which the experiments were made were those of the sides, masthead, binnacle, and a number of the lamps in the interior of the steamer. The result was in every way satisfactory. The flame produced was very bright and steady, and threw the light well out all around. In respect of clearness and steadiness it far surpasses the ordinary oil lamps. The lighting of the vessel was superintended by Mr. Alexander Shaw, acting on behalf of Messrs. H. Bennett and Co., Glasgow, who have the contract.

CABLE COMPETITION.—"The reduced tariff," says the *New York Mail*, "for cable business between this country and Europe will go into operation to-morrow. The Commercial Cable Company, which has two cables, will reduce its tariff from 40 cents to 25 cents per word. The Anglo, which has four cables; the Western Union, which has two cables; the Direct and the French Companies, which have each one cable, will all reduce from a tariff of 40 cents to 12 cents a word. Consequently the public may expect that, for a few months to come, or, possibly, years, there will be sharp competition, and, perhaps, lower rates. The Anglo, the Western Union, the Direct and the French Companies—four companies with eight cables—are not only entirely out of debt, but they have a reserve fund of nearly $7,000,000. The Commercial Cable Company has, we are informed, a bonded indebtedness of $3,000,000. Cable business should be very lively with these rates, by which, for a comparatively small sum, important messages may be sent. Some pessimistic persons imagine that this cable war rate must necessarily be for a short time only, but there is no certainty on that point, and at all events the public should utilise it while it lasts."

THE TELEPHONE AND RIFLE RANGES.—Experiments have been carried on at the Browndown Rifle Ranges, Portsmouth, to see the value of the telephone for the purpose of the marker giving the result of each shot by means of that instrument, instead of by the usual course of flag signalling. The experiments thus far have been very successful. The system employed is similar to that arranged for the diving experiments on board Her Majesty's ships "Vernon" and "Excellent." The apparatus for it was arranged—as has been that in this case—by the Western Counties and South Wales Telephone Company. The advantages of this system over the old system are various. In the first place, the click of the rifle can be distinctly heard, which prepares one to watch the target for the mark, and thus relieves the eyes from the constant watching of the white glaring target. Again, the man can give the actual result of each shot, whether to the "right," "left," "above," "below," or a "miss," and give the *exact* result, whereas the flags could give but very imperfect imformation. Mr. Hovell, who has carried out these experiments, thinks that ultimately the system will be universally used, and he will continue his experiments with the object of still further perfecting it.

RECORDING VOTES.—An intricate and interesting machine says the *Electrical World*, which for over two years has stood in one of the committee rooms of the House of Representatives, is to be removed. It has an interesting history. An old gentleman named Crosby, noticing with some degree of annoyance the immense amount of time lost in the calling of the yeas and nays, undertook to invent a machine which could record the votes almost instantaneously by the means of electricity. There were to be electric buttons at each Congressman's desk. The pressure of one recorded yea and the pressure of the other recorded nay upon a printed slip at the clerk's desk, while at the same time an ingenious arrangement moved the hands on the dial on the Speaker's desk and showed at a glance how many votes had been cast on each side. The inventor, after having had an expensive model made, was taken sick, and was compelled to spend nine months in Florida. The next session was a busy one, and he could get no one to listen to a dissertation on the merits of his invention. This year his son fell sick and died, and he was not able to urge upon Congress the adoption of his machine. The Speaker will probably give orders to have the apparatus removed, for it fills up considerable space. Mr. Crosby wanted 75,000 dollars from the Government for his invention.

THE BRITISH ASSOCIATION.—The programme of arrangements for the Birmingham meeting of the British Association has just been issued. It meets on Wednesday, September 1, when Sir Lyon Playfair resigns the presidency, and will be succeeded by Sir William Dawson, C.M.G., F.R.S., the eminent Canadian geologist, Principal of M'Gill College, Montreal. In the permanent staff there is no alteration, except that the new secretary, Mr. A. S. Atchison, assumes full responsibility for the first time in place of Prof. Bonney. The local secretaries are Mr. J. Barham Carslake, the Rev. D. H. W. Crosskey, and Mr. C. J. Hart, and the local treasurer is Mr. J. D. Goodman. The following are the presidents of the various sections:—Section A (Mathematical and Physical Science), Prof. G. H. Darwin, F.R.S.; Section B (Chemical Science), William Crookes, F.R.S.; Section C (Geology), Prof. S. G. Bonney, F.R.S.; Section D (Biology), William Carruthers, F.R.S.; Section E (Geography), General Sir F. J. Goldsmid, K.C.S.I., C.B.; Section F (Economic Science and Statistics), John Biddulph Martin, F.S.S.; Section G (Mechanical Science), Sir James N. Douglass, M.I.C.E.; Section H (Anthropology), Sir George Campbell, K.C.S.I., M.P. Great efforts are being made in Birmingham to render the meeting an unprecedented social as well as scientific success. Already several of the sectional committees have had meetings to organise the work of their section.

THE SUBMARINE CABLE CONVENTION.—A conference of delegates of the Powers who were parties to the Convention of the 14th March, 1884, reassembled at Paris on Wednesday. The British delegates are—Mr. Kennedy, C.B, head of the Commercial Department of the Foreign Office; Mr. Trevor, C.B., Assistant Secretary to the Board of Trade; and Mr. Lamb, head of the Telegraph Branch of the Post Office. Mr. Farnall, of the Foreign Office, will be secretary to the British delegates. An influential deputation representative of the telegraphic interest had an interview on Tuesday afternoon with Mr. Mundella at the Board of Trade. Lord Tweeddale introduced the deputation, which consisted of the Marquis of Tweeddale, Mr. Pender, Sir James Anderson, Mr. Weaver, Mr. J. W. Fuller, Mr. Colmache, Mr. Hesse, Mr. Wells, and Mr. Burt. The proceedings were private. The deputation waited upon Mr. Mundella to obtain for the Submarine Telegraph Companies the privilege of being represented at the Conference to be held this week in Paris to

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consider the alterations in the International Convention for the protection of submarine cables which were made last year by an Act of the British Parliament. The Foreign Office and Board of Trade acceded to this request, and Lord Tweeddale, Mr. Pender, Mr. Weaver, Sir James Anderson, and other gentlemen representing the different companies interested proceeded to Paris to watch the proceedings of the Conference in the interests of submarine telegraphy. The Congress opened on Wednesday at the Ministry of Foreign Affairs, presided over by M. de Freycinet, who was assisted by M. Granet, the Minister of Posts and Telegraphs. Twenty-four countries were represented. After a speech of welcome to the foreign representatives by M. de Freycinet, the Congress elected M. Felix Granet president, and M. d'Albareda, the Spanish Ambassador in Paris, vice-president. Germany was not represented, but sent a note by the German Ambassador promising adhesion to whatever arrangement may be decided.

THE ELECTRIC ARC.—The resistance of the electric arc, says the *Centralblatt für Electrotechnick*, has been for a long time the object of zealous study. By the work of Edlund, whose results have been verified since by Frölich and Peukert, the presence of an E.M.F. in the arc had become very probable, though no one was able to prove its existence. This so long vainly-sought proof has been given by the ingenious method of Victor *v.* Lang (*Centralbl. f. Elektrotechn* Bd. 7, S. 443). No objections to his method and its results have been made except one lately by Prof. Rühlmann. He says, "It is hardly in accordance with the formula found by Edlund and Frölich that the middle spherical brightness of the arc lights, in which one would expect a proportionality with the product Ei, increases in a considerably stronger ratio than the first power of the current." This objection would be well founded if it were possible to speak of the mechanical equivalent of light. But there is no such equivalent for light as exists for heat, but every kind of ray possesses its own equivalent. It is on this account that in incandescent lamps, within practical limits, the amount of light is proportional to the sixth power of the current, and the electric energy required for a normal candle-power diminishes considerably with the rise in temperature of the carbons. The above objection is consequently not well founded, and the existence of the E.M.F. is not thereby brought into question. The interesting question now is, where is the seat of the opposing E.M.F. As the positive electrode gives the most light probably a large amount of work is done there, and that the fall of potential in the first half of the arc is greater than in the second half. This research has its difficulties, because the probe which you must bring into the arc is exposed to a very high temperature. Thence it is necessary to surround it with tubes of insulating material. Clay porcelain or stealite may be used for the tubes, but the latter two are the better, because they do not melt so readily. The resistance of the probe and its connections should be very great, that the arc light may not be affected by its introduction. So far as the researches hitherto made go the following laws may be taken as substantially correct:—
I. In the arc light there exists an E.M.F., independent of the length and of the strength of the current, of about 39 volts.
II. The resistance of the arc light is proportional directly to the length and inversely to the current strength. The cross section of the arc light is proportional to the current.

SPAIN AND SUBMARINE CABLES.—We notice in the *Revista Telégrafica* of Madrid for May a long and interesting article on the position of Spain with regard to submarine cables, showing that, due to its geographical situation, that country should be an important intermediary between the new world and a great portion of Europe. It strongly insists on the necessity of the construction of direct land lines, in connection with, and exclusively in the service of, those cables which are landed on the Spanish coast, and it believes that were the Government to assure the erection of such lines, many cable schemes now in abeyance for the want of good through communication would be carried out, with the result of a large increase to the telegraph revenue. As an instance, a cable between Cartagena and Malta would certainly be laid were the Government to construct an international land line between Cartagena and Bilbao. Nor would there be much difficulty in obtaining a cable between Minorca and Sardinia, should the Government grant a direct and efficient line to Portugal, as the trade between that country and Italy is a very large one. The article calls attention to the absence of telegraphic communication between the Peninsula and Centa, one of the most important fortified places, and of great strategic value as regards naval operations. It is suggested that it would by no means be difficult to arrange for the laying of this cable were the Government to make certain concessions, such as permission to extend the cable to Tangiers and other ports on the West coast of Morocco, or the payment of a small subsidy, or the guarantee of a moderate interest on the capital employed. It is pointed out that in view of the possibility of the carrying out of the long-talked of scheme of a cable between the Canary Islands and Puerto Rico, the line from Spain to Centa and Tangiers might be continued to the Rio de Oro and the Canary Islands, thus assuring a duplicate communication. Another cable suggested as being important to Spanish interests would be between Cartagena and Oran, for the trade between these places is already very extensive and is increasing, and the number of Spanish colonists in the latter place is large and rapidly augmenting, for it is found that Spaniards can stand the climate much better than the French. Among cable enterprises mentioned as likely to be carried out before long is the scheme, which for some time has greatly interested the German Minister of Posts and Telegraphs, for a direct cable between Emden and Coruña, the idea being to secure a communication entirely independent of any English or French lines.

PHOTOGRAPHY AND ELECTRICITY.—Dr. Boudet, of Paris, in the *Bulletin de la S. J. des Electriciens*, describes the photographic reproduction of the luminous effect of electricity without the intervention of ordinary photographic apparatus. The results recorded originated from experiments in determination of conductivity of rarefied gases. Wishing to photograph the different kinds of sparks obtained, he essayed with ordinary photographic apparatus and obtained very imperfect results. On lately repeating the experiments, he employed another method to obtain photographs of the sparks, by operating directly on the gelatine bromide of silver plate. He says: "A photographic plate being put flat (the sensitive side upward), I placed above it, at a certain distance from one another, two pieces of money, one of five francs, the other of 50 centimes. I charged one of the condensers; then, putting its exterior armature in connection with the piece of five francs, I placed the metal knob of the interior stalk (*i.e.*, what was practically the knob connected with the interior coating of a Leyden jar) on the piece of 50 centimes. The spark immediately passed between the two pieces. I repeated the same operation for each kind of condenser, then I carried the plate to the ordinary baths for fixing and showing. Here are the stereotype plate and the positive proof which I obtained. You see that all the characteristic details of each discharge are there reproduced with the greatest fidelity. My aim was attained." He goes on to say how he tried the same thing with the current and the discharge of a Voss machine, and found

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that the impress of the coins was reproduced in the photograph of the sparks. On this discovery he placed one of the coins over the centre of the sensitive plate, and moved the other round it while the discharge took place. The result was a photograph reproducing perfectly all the details of the stationary coin. He then placed pieces of thick paper with figures on them, in ink or other black matter, between a metal disc and the photographic plate, and found after the passage of the spark a photograph of the figures on the sensitive plate. He found the effect improved by placing a mirror behind the sensitive plate in this case. He found the current (*i.e.*, a continuous discharge) to act better than sparks. He attributes the effect produced solely to the illuminating power of the discharge. He sums up thus:—"The illumination produced by the electric discharge and reflected by a mirror enables you to reproduce with all details of engraving and drawing any plain object placed over a sensitive plate of gelatine-bromide of silver." He expects soon to reproduce the same effects by means of any brilliant light, whether electric or not.

ELECTRICITY ON BOARD THE "TAKACHIHO KAN."—The magnificent cruiser "Takachiho," built for the Imperial Japanese Navy by Messrs. Sir W. G. Armstrong, Mitchell, and Co., left the Tyne on her voyage to Japan on the 6th inst. This vessel, which is of 3,600 tons displacement and over 7,500 horse-power, is, excepting only her sister ship, the "Naniwa," the fastest and most redoubtable cruiser in the world, her mean speed of 18·8 knots being at present unequalled by any other ship of her class. On each of these vessels (the two are precisely similar in every detail) electricity is well to the fore. The two 25 ton 10in. and six 6in. guns are all fitted with electric firing gear, so that by merely pressing a key in the armour covered tower on the forward bridge the officer in command can fire a simultaneous broadside of five guns. The correct aim is obtained by means of an instrument called a *director*, which is a species of fixed adjustable telescope, the guns being so laid that if fired when a part of the target is visible through the director, the several projectiles will all strike at identically the same place, a point of great importance when armoured ships are being attacked. The ship is also fitted with four tubes for discharging locomotive torpedoes, which are fired electrically from stations on the upper deck in a similar manner to the guns. Each tube has, however, its own director and firing key, and is independent of its neighbours. As regards electric lighting, the two engine rooms, the stokeholes, coal bunkers, magazines, captain's cabins, and chart room are fitted throughout with 16 candle-power Swan incandescent lamps, 108 in all being employed. There are also four arc search lights, each of 25,000 candle-power, two on each bridge. The generating plant consists of four dynamo machines, driven by two of Messrs. Goodfellow and Mathew's compound "triplex" engines. Two of the dynamos with their engine are fixed in the forward part of the vessel, while the other two are placed in the forward engine room, all being below the water line, and beneath the 3in. protective steel deck, which covers all the vitals of the ship. A system of trunk wires between the switch-boards at the two dynamo stations permits of any dynamo being connected to any of the four search light or eight incandescent lamp circuits. The whole of the electric light installation, including search and incandescent light circuits and trunk connections, is wired on the double wire system according to a new and original plan worked out by Mr. A. A. Campbell Swinton, electrician to Messrs. Sir W. G. Armstrong, Mitchell, and Co., by means of which the usual unsightly and costly wood casing is entirely done away with, the wires, great and small, main and branch, being covered with a watertight skin of lead, which sufficiently protects the insulator without further covering. This arrangement, while presenting a particularly neat appearance, has proved very efficient and satisfactory in practice. The entire lighting and other electrical installations have been fitted up by the electrical department of Messrs. Sir W. G. Armstrong, Mitchell, and Co., who built both vessels.

VITAL POLARITY.—The following is an abstract of a paper on this subject by Albert de Rochas in *Cosmos* of April 19th, 1886. The author says that a new scientific fact has been discovered by a great French manufacturer, whose name he does not give. It has been formerly noticed by several observers that there were certain sensitive persons who were incommoded by contact with other persons in particular positions, and that these same persons received a different impression from the north and south poles of a magnet, from the summit and base of a crystal, &c. In the dark they saw gleams of light emanating from the human body, from plants, from the poles of a magnet, &c. In other cases the approach of a magnet and electricity have had a soporific effect. M. D——, by his patience and sagacity, seems to have established a link by which these incoherent observations may be brought within the grasp of methodical science. The following shows the nature of the experiments which serve to throw light on the matter. Let us take one of these sensitive persons fully awake. I touch the external part of his little finger with the positive electrode of a battery, or the north pole of a magnet. At the end of some seconds the little finger is stiffened. The same effect would have been produced if I had touched it with the flower of a plant, an acid, my own little finger, or even with the little finger of his other hand, a piece of gold or silver, &c. If I afterwards touch the same part of the stiffened little finger with the negative electrode of a battery, the south pole of a magnet, the stalk or root of a plant, a basic body, my thumb or his own, a piece of nickel or sulphur, &c., the rigidity ceases. Hence one must conclude that there exists in the first series of bodies mentioned a different dynamide from what there does in the second. It is natural to designate the 1st by the name of positive, and the 2nd by that of negative. This is what M. D.—— has done. By making use of alternately positive and negative bodies, he has succeeded in arriving at the distribution of the dynamides on the human body. The head and trunk are positive on the left side and negative on the right, both before and behind. The arms and the legs are positive on the side of the little finger and negative on the side of the thumb or great toe. Moreover, each finger is polarised in the same manner, so that in shutting or parting the fingers the process is the same as bringing together or parting the discs of a voltaic pile. Animals living or dead have the same distribution of polarity as man. Living or dried plants are positive at the flower end and negative at the root end. A fruit is negative at the stalk end, and positive at the other. Inorganic bodies have only one dynamide, or are as wholes either positive or negative. Any two polarities of the same sign placed in contact (or even simply brought near one another if their energy is sufficient) produce a rigidity or repulsion; two polarities of different sign under the same conditions produce a cessation of this rigidity or attraction. These phenomena are translatable by the different actions which arise at different parts of the body. The author goes on to describe the peculiar effect on certain persons of the contact of flowers, the approach of magnets, the contacts of each other's hands, fingers, &c.

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PRACTICAL ELECTRICITY FOR AMATEURS.

Electric Bells and Indicators.

Fixing the Wires. — Electric bells are now used very extensively in all classes of buildings, and the arrangements vary to suit the particular requirements of each case. The use of electric bells in this country has not been so extensive as on the Continent, where it is the exception to find the old style of bells. In many cases electric bells have got into disrepute from bad workmanship and cheap fitting up, many scores of places having been wired with the commonest wire obtainable, *i.e.*, a small copper wire (about No. 24 B.W.G.) covered with cotton and a coat of paraffin. Such wires, especially in new buildings, rapidly decay—in some cases in a few months—besides causing leakages from, and consequent rapid exhaustion of, the battery.

The smallest wire used should not be less than No. 18 B.W.G., covered with gutta percha to not less than No. 11 B.W.G., and a final covering of cotton or tape to prevent chafing the gutta percha. This for damp or cool situations. Where, however, wires are exposed to high temperatures, such as hot water pipes, &c., the insulating substance should be india rubber. It may be urged that this wire is too expensive; but the result of using cheap wires cannot but be injurious to both buyer and seller, and bad wires can only be renewed at great trouble and expense after a building is completed and finished. Good wiring is far more important than good bells and indicators, as they are readily accessible; not that the use of any bad apparatus is advocated. The cost of the first named cotton covered wire is about £2 per mile, and the kind advocated about £7. 10s. per mile.

The practice of putting the wires into zinc tubes (unless of ample size) is not advocated, the best method, wherever it can be adopted, being a channel in the wall with a wooden cover screwed on. The channels provided for hot water pipes should, if possible, be avoided, as also all forcible dragging at the wires (as is commonly done in forcing a number of wires into small tubes), and where wires run under floors in the same direction as the boards, they should be placed in small notches (just to hold the wire) one inch apart nearly in the centre of the floor board. If near the edge the wires may be injured in screwing down the board. As notches weaken the joist considerably if there are several wires, a better plan is to bore a hole two or three inches from the top edge of joist, as this practically does not weaken them at all. Avoid the use of iron or steel staples.

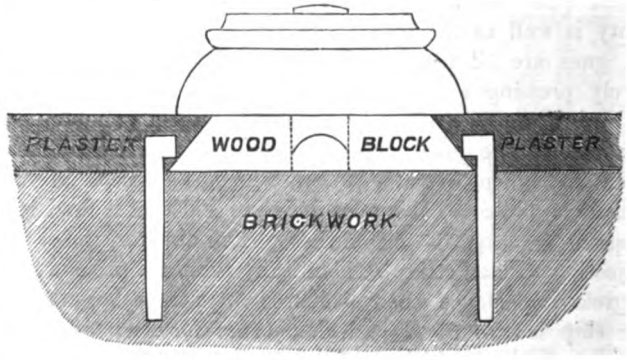
In rooms where there is a push each side of the fireplace it is in most cases preferable to go round over the mantelpiece with the wires (of course sunk in the plaster) to going round or under the hearthstone; the return wire which branches to all the pushes should be of a different colour to that used for the other or outgoing wires, as it facilitates matters in first laying the wires, and in the event of a wire failing there is no difficulty in identifying the wire both at the push and at the battery end. Special care must be taken in jointing the wire at branches, &c.; all joints must be soldered with composite candle or resin—*never use spirits.* When soldered, the joint must be well covered with elastic glue, or rubber tape and then firmly bound over with tape to prevent contact with other wires.

To solder a joint properly without burning up the insulation on each side, the following articles must be provided:—A small spirit lamp, a small copper bit made from about 2 inches of No. 8 copper wire, drawn to a blunt point at one end, with a steel wire screwed into the other end, and this wire driven into a small handle; a small tin box to hold a piece of composite candle or powdered resin; and, lastly, a small quantity of the best blowpipe solder, *i.e.*, tin two parts, lead one part. The copper bit, when new, and at intervals afterwards, will require tinning, which is done thus: Make the bit bright with emery paper or a file, heat it in the spirit lamp, and rub it on a piece of sheet tin with some solder and composite or resin. This should give it a bright tinned surface. Now, to solder a joint, scrape the wires bright, twist them firmly together, rub well over with composite, or dust the joint with resin, heat the copper bit in the lamp, wipe the joint with a piece of rag, touch it on the composite or resin, then on the solder, so that a small piece adheres, and apply it to the joint, rubbing it along. If this is properly done, a strong clean joint is the result.

In removing the covering of any insulated wire never cut square through the covering, but draw the knife parallel with the wire. The first method in all probability makes a slight nick on the wire, and if this is done the wire will break there even if only slightly bent, and consequently cause a fault which may be difficult of access.

In new buildings the position of the pushes should be determined as early as possible, so that the wires may be brought to the appointed places. If tubes are used they should be placed in position before the walls are plastered or floors laid; an uninterrupted run can then be secured from top to bottom of the building. The exact position of the pushes cannot usually be determined until the plastering is done, and the chimney pieces fixed; care must also be taken that the requisite flooring boards are *screwed* and *not nailed down*, so that they may be readily removed when laying the wires. When the position of the pushes is determined, the plaster must be cut away to admit a round, bevelled block of wood (mahogany and elm are very suitable).

This must be set in plaster flush with the surface, the bevelled shape holding it firmly. It is as well, however, to drive two or three floor brads into the joints in the brickwork, the heads embracing the edge of the wood block so as to leave a clear surface to screw on the push. The block should on the face nearest the push be at least ½in. less in diameter, so as to allow the slight adjustment of the latter without exposing the block. The wood is such good fixing that the extra trouble is amply repaid. The annexed sketch will explain the above. On



lath and plaster walls blocks are not necessary, as by using a long slender pricker to find the lath and fine-pointed lath screws a good hold can always be obtained.

Bells.—The bell in ordinary use (Fig. 1) consists of an electro-magnet provided with a vibrating armature, A, carrying the bell hammer, H, a spring, S; the back of this in its normal position comes into contact with a contact post, P. When the current is allowed to circulate in the coils of the electro-magnet the armature is attracted, the hammer thereby striking the bell, and at the same time the spring leaves the contact post, thereby breaking the circuit, thus causing the armature to fall back by the pressure of the spring, which again makes contact with the post, thus causing a rapid vibration of the armature, and consequently the ringing of the bell.

To adjust an electric bell, it will be necessary to see that all the connections are tight, screw post, P, and screw, *b*, firm, and not shaking about; hold the hammer head H against the bell, then adjust the screw *b*, so that it just clears the platinum point or spring. See also that the armature A is quite clear from touching the poles P P. When the hammer is released the spring should draw the armature back, and the platinum point should make *good contact* with the screw *b*. It sometimes happens that a bell rings badly from the spring not setting the armature back strongly enough. In order to know if this is the case, press lightly (with a springy piece of wire) the armature away from the poles whilst the bell is ringing. If the ringing improves the spring and armature must be taken

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off and the spring *set out a little* close to the fixed end. If the ringing improves when the wire is pressing the armature against the poles the spring is too strong, and must be *set in a little.* The best bells are those mounted on an iron frame independently of the outer wooden case. Never use uncovered bells, as the dust gets into the contact, thus preventing their proper working. See that the contacts are really platinum, and not a white metal, such as German silver, the use of which is very common.

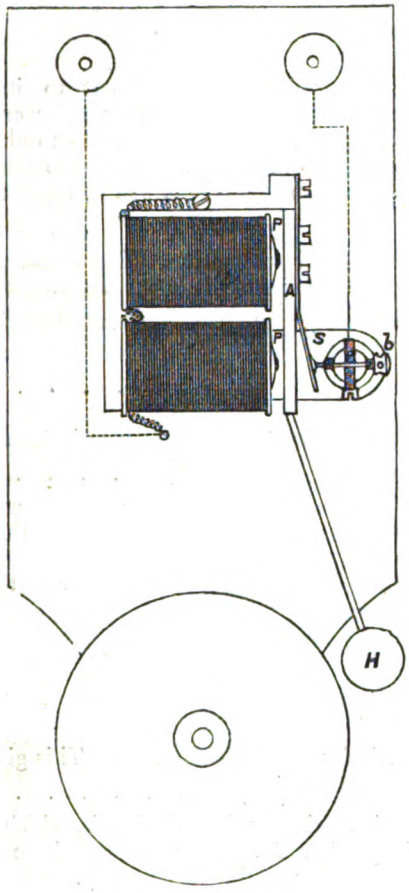

FIG. 1.

Where it is necessary to have two or more bells in one circuit, it is a very great advantage to be able so to arrange

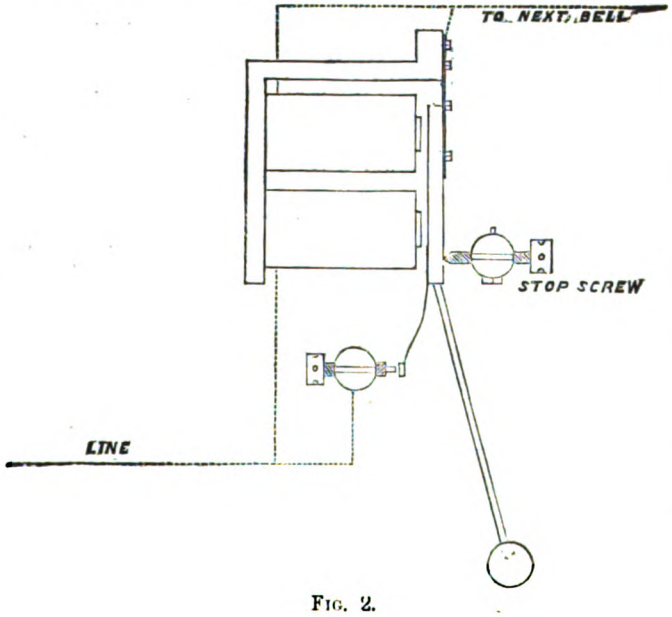

FIG. 2.

them that the ringing of one will not interfere with the ringing of the remainder. This is sometimes attained by employing one vibrating, and the remainder single-stroke bells, the whole being in series. Another plan is to place the bells (constructed as shown in Fig. 2) in series, when each bell governs its own vibrations, not by breaking the circuit, but by shunting its own coils. Directly the armature falls back the coils are again put in circuit and the armature again attracted. Bells arranged in this manner, however, do not ring so energetically as ordinary bells with a corresponding amount of battery power.

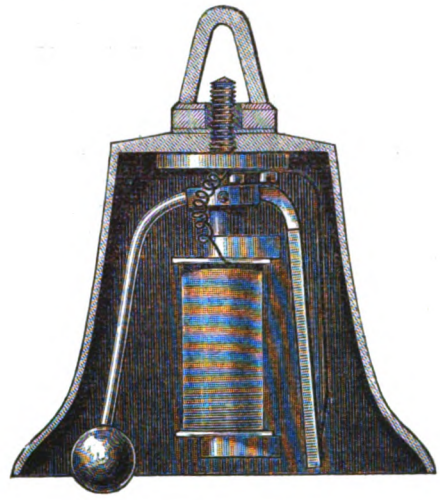

FIG. 3.

Electric bells are now made in the form shown by Fig. 3 A bell in the form of an ordinary church bell is used, having a single magnet of special construction, in which the armature, besides being magnetised by special induction, is directly polarised by being in actual magnetic contact with the iron coil of the magnet; it is thus induced to perform a large amount of work with comparatively small power. It is a very compact and simple arrangement; is by no means unsightly, and the tone pleasant.

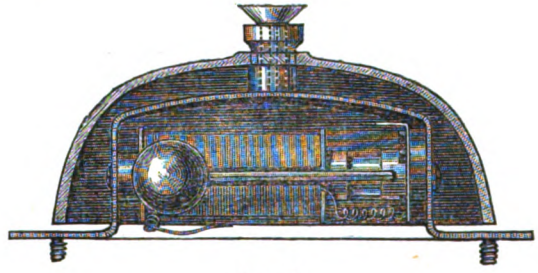

FIG. 4.

Fig. 4 shows a compact form of bell, which is also fitted with a responding attachment, so that a person ringing to a servant

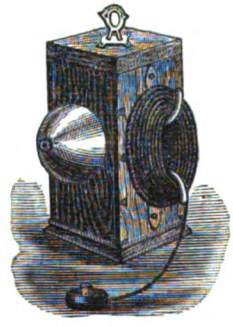

FIG. 5.

can receive (by the servant pressing the button on the bell) an intimation that the summons has been heard and will be attended to.

These modifications are known as the "Jensen System."

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For temporary purposes a convenient and portable form of electric bell and battery, with a long flexible silk conducting cord and push, as shown by Fig. 5, is very convenient.

(To be continued.)

ELECTROMAGNETIC INDUCTION AND ITS PROPAGATION.

BY OLIVER HEAVISIDE.

(Continued from page 470, Vol. XVI.)

The Transient State in a round wire with a close fitting tube for the return current.

The propagation of magnetic force and of electric current (a function of the former) in conductors takes place according to the mathematical laws of diffusion, as of heat by conduction, allowing for the fact of the electric quantities being vectors. This conclusion may perhaps be considered very doubtful, as depending upon some hypothesis. Since, however, it is what we arrive at immediately by the application of the laws for linear conductors to infinitely small circuits (with a tacit assumption to be presently mentioned), it seems to me more necessary for an objector to show that the laws are not those of diffusion, rather than for me to prove that they are.

We may pass continuously, without any break, from transient states in linear circuits to those in masses of metal, by multiplying the number of, whilst diminishing the section of, the "linear" conductors indefinitely, and packing them closely. Thus we may pass from linear circuits to a hollow core, from ordinary linear differential equations to a partial differential equation, from a set of constants, one for each circuit, to a continuous function, viz., a compound of the J_0 function and its complementary function containing the logarithm. This I have worked out. Though very interesting mathematically, it would occupy some space, as it is rather lengthy. I therefore start from the partial differential equation itself.

Our fundamental equations are, in the form I give to them,

$$\text{curl}.\mathrm{H} = 4\pi\mathrm{C}, \qquad -\text{curl}\,\mathrm{E} = \mu\mathrm{H}, \quad \mathrm{C} = k\mathrm{E}. \quad . \quad (1b)$$

E and H being the electric and magnetic forces, C the conduction current, k and μ the conductivity and the inductivity. The assumption I referred to is that the conductor has no dielectric capacity. Bad conductors have. We are concerned with good conductors, whose dielectric capacity is quite unknown.

We are concerned with a special application, and therefore choose the suitable co-ordinates. All equations referring to this matter will be marked *b*. The investigations are almost identical with those given in my paper on "The Induction of Currents in Cores," in *The Electrician* for 1884. The magnetic force was then longitudinal, the current circular; now it is the current that is longitudinal, and the magnetic force circular.

The distribution of current in a wire in the transient state depends materially upon the position of the return conductor, when it is near. The nature of the transient state is also dependent thereon. Now, if the return conductor be a wire, the distributions in the two wires are rendered unsymmetrical, and are thereby made difficult of treatment. We, therefore, distribute the return current equally all round the wire, by employing a tube, with the wire along its axis. This makes the distribution symmetrical, and renders a comparatively easy mathematical analysis possible. At the same time we may take the tube near the wire or far away, and so investigate the effect of proximity. The present example is a comparatively elementary one, the tube being supposed to be close fitting. As I entered into some detail on the method of obtaining the solutions in "Induction in Cores," I shall not enter into much detail now. The application to round wires with the current longitudinal was made by me in *The Electrician* for Jan. 10, 1885, p, 180, so far as a general description of the phenomenon is concerned. See also my letter of April 23, 1886.

Let there be a wire of radius a, surrounded by a tube of outer radius b, and thickness $b-a$. In the steady state, if the current density is Γ in the wire, it is $-\Gamma a^2/(b^2-a^2)$ in the tube, if both be of uniform conductivity, and the tube or sheath be the return conductor of the wire. Let H_1 be the intensity of magnetic force in the wire, and H_2 in the tube. The direction of the magnetic force is circular about the axis in both, and the current is longitudinal. We shall have

$$\mathrm{H}_1 = 2\pi\Gamma r, \qquad \mathrm{H}_2 = -2\pi\Gamma a^2(r^2-b^2)/r(b^2-a^2), \quad . \quad (2b)$$

where r is the distance of the point considered from the axis. Test by the first of equations (1*b*). We have

$$\text{curl} = \frac{1}{r}\frac{d}{dr}r,$$

when applied to H.

Now let this steady current be left to itself, without impressed force to keep it up, so that the "extra current" phenomena set in, and the magnetic field subsides, the circuit being left closed. At the time t later, if the current density be γ at distance r from the axis, it will be represented by

$$\gamma = \Sigma\,\mathrm{A}\mathrm{J}_0(nr)\epsilon^{pt}, \quad . \quad . \quad . \quad . \quad . \quad (3b)$$

where Σ is the sign of summation. The actual current is the sum of an infinite series of little current distributions of the type represented, in which A, n, and p are constants, and $\mathrm{J}_0(nr)$ is the Fourier cylinder function. We have

$$\frac{1}{r}\frac{d}{dr}r\frac{d\gamma}{dr} = 4\pi\mu k\gamma \quad . \quad . \quad . \quad . \quad . \quad . \quad (4b)$$

Let $d/dt = p$, a constant, then n is given in terms of p by

$$n^2 = -4\pi\mu kp \quad . \quad . \quad . \quad . \quad . \quad . \quad (5b)$$

We suppose that k and μ are the same in the wire as in the sheath. Differences will be brought in in the subsequent investigation with the sheath at any distance.

In (3*b*) there are two sets of constants, the A's fixing the size of the normal systems, and the n's or p's, since these are connected by (5*b*). To find the n's, we ignore dielectric displacement, since it is electromagnetic induction that is in question. This gives the condition

$$\mathrm{H}_2 = 0, \text{ at } r = b; \quad . \quad . \quad . \quad . \quad . \quad . \quad (6b)$$

i.e., no magnetic force outside the tube. This gives us

$$\mathrm{J}_1(nb) = 0, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7b)$$

as the determinantal equation of the n's, which are therefore known by inspection of a Table of values of the J_1 function.

Find the A's by the conjugate property. Thus,

$$\mathrm{A} = \frac{\Gamma\int_0^a \mathrm{J}_0(nr)\,rdr - \int_a^b \Gamma a^2\mathrm{J}_0(nr)rdr/(b^2-a^2)}{\int_0^b \mathrm{J}_0^2(nr)rdr}$$

$$= 2a\Gamma\mathrm{J}_1(na)/n(b^2-a^2)\mathrm{J}_0^2(nb) \quad . \quad . \quad . \quad . \quad . \quad (8b)$$

The full solution is, therefore,

$$\gamma = \{2a\Gamma/(b^2-a^2)\}\,\Sigma\,\mathrm{J}_1(na)\mathrm{J}_0(nr)\epsilon^{pt}/n\mathrm{J}_0^2(nb). \quad . \quad (9b)$$

giving the current at time t anywhere.

The equation of the magnetic force is obtained by applying the second of equations (1*b*); it is

$$\mathrm{H} = \{8\pi a\Gamma/(b^2-a^2)\}\,\Sigma\,\mathrm{J}_1(na)\mathrm{J}_1(nr)\epsilon^{pt}/n^2\mathrm{J}_0^2(nb); \quad . \quad . \quad (10b)$$

and the expression for the vector potential of the current (for its scalar magnitude A_0, that is to say, as its direction, parallel to the current, does not vary, and need not be considered), is

$$\mathrm{A}_0 = \{8\pi\mu a\Gamma/(b^2-a^2)\}\,\Sigma\,\mathrm{J}_1(na)\mathrm{J}_0(nr)\epsilon^{pt}/n^3\mathrm{J}_0^2(nb). \quad . \quad (11b)$$

This may be tested by

$$\text{curl}.\mathrm{A} = \mu\mathrm{H}; \quad . \quad . \quad . \quad . \quad . \quad (12b)$$

curl being now $= -d/dr$. In the steady state (initial), $t = 0$,

$$\left.\begin{aligned} &\mathrm{A}_0 = \mu\pi\Gamma\{-r^2 + 2a^2b^2\log(b/a)/(b^2-a^2)\}, \\ &\text{in the wire, and} \\ &\mathrm{A}_0 = \{\mu\pi\Gamma a^2/(b^2-a^2)\}\{-b^2 + r^2 + 2b^2\log(b/r)\} \end{aligned}\right\} \quad . \quad (13b)$$

in the sheath. Test by (12*b*) applied to (13*b*) to obtain (2*b*).

The magnetic energy being $\mu\mathrm{H}^2/8\pi$ per unit volume, the amount in length l of wire and sheath is by (10*b*)

$$\mathrm{T} = (\mu l/8\pi)\{8\pi a\Gamma/(b^2-a^2)\}^2\Sigma\int\frac{\mathrm{J}_1^2(na)\mathrm{J}_1^2(nr)}{n^4\mathrm{J}_0^4(nb)}2\pi rdr\epsilon^{2pt}.$$

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To verify, this should equal the space integral of $\frac{1}{2}A_0\gamma$, using (11b) and (9b). This need not be written. They are identical because

$$\int_0^b J_0^2(nr)\,rdr = \int_0^b J_1^2(nr)rdr = \tfrac{1}{2}b^2J_0^2(nb),$$

so that we may write the expression for T thus,

$$T = \tfrac{1}{2}\mu l\{4\pi a\Gamma b/(b^2-a^2)\}^2 \Sigma\, J_1^2(na)\,\epsilon^{2pt}/n^4J_0^2(nb) \quad (14b)$$

The dissipativity being γ^2/k per unit volume, the total heat in length l of wire and sheath is, if $\rho = k^{-1}$, the resistivity, and the complete variable period be included,

$$Q = \rho\{2a\Gamma/(b^2-a^2)\}^2 \Sigma \frac{J_1^2(na)\,\frac{1}{2}b^2J_0^2(nb)\,2\pi l}{n^2J_0^4(nb)\,(-2p)} \quad . \quad . \quad (15b)$$

When $t=0$, either by (14b) or by easy direct investigation, the initial magnetic energy in length l is

$$T_0 = \mu l(\tfrac{1}{2}\pi\Gamma a^2)^2\left\{1 + \frac{b^2+a^2}{b^2-a^2} - \frac{4b^2}{b^2-a^2} + \frac{4b^4}{(b^2-a^2)^2}\log\frac{b}{a}\right\}, \quad (16b)$$

giving the coefficient of self-induction of length l as

$$L = \mu l[-b^2/(b^2-a^2) + \{2b^4/(b^2-a^2)^2\}\log(b/a)], \quad . \quad . \quad (17b)$$

to be got in other ways. This refers to the steady state. In the transient state there cannot be said to be a coefficient of self-induction, as the distribution varies with the time. The expression in (15b) for the total heat may be shown to be equivalent to that in (16b) for the initial magnetic energy, thus verifying the conservation of energy in our system.

I should remark that it is the same formula (9b) that gives us the current both in the wire and tube, and the same formula (10b) that gives us the magnetic force. They are distributed continuously in the variable period. It is at the first moment only that they are discontinuous, requiring then separate formulæ for the wire and tube, *i.e.*, separate *finite* formula, although only a single infinite series.

The first term of (9b) is, of course, the most important, representing the normal system of slowest subsidence. In fact, there is an extremely rapid subsidence of the higher normal systems; only three or four need be considered to obtain almost a complete curve; and, at a comparatively early stage of the subsidence, the first normal system has become far greater than the rest. In fact, on leaving the current without impressed force, there is at first a rapid change in the distribution of the current (and magnetic force), besides a rapid subsidence. It tends to settle down to be represented by the first normal system; a certain nearly fixed distribution, subsiding according to the exponential law of a linear circuit.

To see the nature of the rapid change, and of the first normal system, refer to *The Electrician* of Aug. 23, 1884, where is a representation of the J_0 and J_1 curves. In Fig. 1, p. 339, take the distance OC_2 to be the outer radius of the tube, O being on the axis. Then the curve marked J_1 is the curve of the magnetic force, showing its comparative strength from the centre of the wire to the outside of the tube, in the first normal system. And, to correspond, the curve vv from O up to C_2 is the curve of the current, showing its distribution in the first normal system.

We see that the position of the point B_1 with respect to the inner radius of the sheath determines whether the current is transferred from the wire to the sheath, or *vice versâ*, in the early part of the subsidence. If the sheath is very thin, so that the radius of the wire extends nearly up to C_2, there is transfer of the sheath current (initial) from the sheath a long way into the wire. On the other hand, if the wire be of small radius compared with the outer radius of the tube, so that the tube's depth extends from C_2 nearly up to O, there is a transfer of the original wire current a long way into the thick sheath. In Fig. 2 on the same page are shown the first four normal systems, all on the same scale, as regards the vertical ordinate, but we are not concerned with them at present.

Since $-p^{-1} = 4\pi\mu kb^2/(nb)^2$,

by (5b), and $-p^{-1}$ is the time constant of subsidence of a normal system, we have, for the value of the time constant of the first system, $-p_1^{-1} = \cdot 273\,\pi\mu kb^2$,

because the value of the first nb, say n_1b is 3·83. Compare this with the linear theory time constant L/R, where L is given by (17b), and R is the resistance of length l of the wire and sheath (sum of resistances, as the current is oppositely directed in them). Let $a = \frac{1}{2}b$. Then

$$L = 1\cdot 128\,\mu l.$$

We have also

$$R = 16l/3\pi kb^2, \qquad \text{therefore } L/R = \cdot 211\,\pi\mu kb^2,$$

so that the time constant of the first normal system is to that of the current in wire and tube on the linear theory as ·27 to ·21. But it is only after the first stage of the subsidence is over that this larger time constant is valid.

We may write the expression for L thus. Let $x = b/a$, then

$$L = \{\mu l x^2/(x^2-1)\}\{2x^2(\log x)/(x^2-1) - 1\},$$

nearly the same as $2\mu l \log x$ when x is large. The minimum is when $b=a$, then $L = \frac{1}{2}\mu l$. This is the least value of the coefficient of self-induction of a round wire, viz., when it has a very thin and close fitting sheath for the return current, so that the magnetic energy is confined to the wire.

When b/a is only a little over unity,

$$L = \{\mu l b^2/(b^2-a^2)\}\{3b^2 - a^2 - 2ab\}/(b+a)^2.$$

We have also $R = lb^2/\pi ka^2(b^2-a^2)$,

and therefore

$$L/R = \pi k\mu a^2[\{2b^2\log(b/a)\}/(b^2-a^2) - 1].$$

Irrespective of b/a being only a little over unity, we have,

with $a/b = \frac{1}{10}$, $L/R = \cdot 009(4\pi\mu kb^2)$,
" $\frac{1}{20}$, " ·053 " ,
" $\frac{1}{40}$, " ·020 " ;

whilst the time constant of the first normal system in all three cases is $\cdot 068(4\pi\mu kb^2)$.

The maximum of L/R with b/a variable is when

$$(x^2-1)(x^3-\tfrac{1}{2})/x^4 = \log x,$$

x being b/a. This value of x is not much different from the ratio of the nodes in the first normal system, or the ratio of the value of r, making $J_1(nr)=0$ for the first time to that making $J_0(nr)=0$. For the latter value makes $\log x = \cdot 465$, and the other side of the last equation to be ·486.

In the subsidence from the steady state, the central part of the wire is the last to get rid of its current. But the steady state has to be first set up. Then it is the central part of the wire that is the last to get its full current. To obtain the equations showing the rise of the current and of the magnetic force in the wire and the tube, we have to reverse or negative the preceding solutions, and superpose the final steady states. As these are discontinuous, there are two solutions, one for the wire, the other for the sheath; but the transient part of them, which ultimately disappears, is the same in both. There is no occasion to write these out.

If the steady state is not fully set up before the impressed force is removed, we see that the central part of the wire is less useful as a conductor than the outer part, as the current is there the least. If there are short contacts, as sufficiently rapid reversals, or intermittences, the central part of the wire is practically inoperative, and might be removed, so far as conducting the current is concerned. Immediately after the impressed force is put on, there is set up a positive current on the outside of the wire, and a negative on the inside of the sheath, which are then propagated inward and outward respectively. If the sheath be thin, the initial (surface) wire current is of greater and the initial sheath current of less density than the values finally reached by keeping on the impressed force; whilst if it be the sheath that is thick the reverse behaviour obtains.

This case of a close fitting tube is rather an extreme example of departure from the linear theory; the return current is as close as possible and wholly envelops the wire current. Except as regards duration, the distributions of current and magnetic force are independent of the dimensions, *i.e.*, in the smallest possible round wire closely surrounded by the return current the phenomena are the same as in a big wire similarly surrounded, except as regards the duration of the variable period. The retardation is proportional to the conductivity, to the inductivity, and to the square of the outer radius of the tube.

When, as in our next section, we remove the tube to a distance, we shall find great changes.

(To be continued.)

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THE ELECTRICIAN.

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All communications to be addressed to 1, *Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

INDEX TO VOLUME XVI.

With our last number a Supplement was issued (Gratis), containing the Index to Vol. XVI. This Supplement should have been received with every copy of the paper. Complaints of non-receipt should be forwarded to the Manager.

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THE SUBMARINE CABLE CONVENTION.

We are glad to be able to announce that, in response to the deputation which waited upon him on Monday, Mr. MUNDELLA acceded to the request of the British Cable proprietors to be represented at the International Conference which formally reassembled at Paris on Wednesday. Lord TWEEDDALE, who took an active part in the debates last year on the Submarine Cable Protection Bill, has accordingly proceeded to the French capital, accompanied by Mr. PENDER, Mr. WEAVER, Sir JAMES ANDERSON, and other gentlemen, to watch the proceedings of the Conference in the interests of the cable companies. It has been one of our complaints against the CONVENTION from the very first that it practically ignores the existence of the owners whose property was under discussion, and gives them no voice whatever in these international decisions. This defect will be partly, though only partly, removed on the present occasion, when it will be no fault of the non-official Delegates if they do not make their presence felt inside the Council Chamber. As on the occasion of the original meeting, two years ago, the British nation is represented solely by Government officials—gentlemen from the Foreign Office, the Board of Trade, and the Telegraph Branch of the Post Office; and although nine-tenths of the cable property of the world belongs to British subjects, and all, or nearly all, of it has been manufactured and laid by British hands, they have no direct voice or vote in the proceedings of the Convention. That the British Government Delegates are not to be implicitly trusted to safeguard the integrity of English property is shown by their acquiescence in international obligations which, put to the test of practical legislation, proved to be either inequitable or unworkable.

It will be in the recollection of our readers that the Paris Convention of 1884 was got together by invitation of the French Government for the purpose of laying down rules for the better protection of submarine cables, for regulating the procedure of vessels employed in laying them, and for the punishment of wilful or culpably negligent breaking of cables already submerged. Some score of nationalities from far and near cheerfully responded to this invitation, the more cheerfully perhaps because most of them had no cable property of their own to regulate. The facts being as we have already stated, and England having an overwhelming interest in this question, one might have thought she would have hesitated to surrender it to the mercy of a majority who were hostile or indifferent to her supremacy. If our Government had declined to attend it, the Convention must have collapsed in the absence of the chief consenting party. But the Foreign Minister of that day was sedulously cultivating the friendship of France, and one way of doing this was to humour her fancy for international pronouncements. Matters might have been worse; the Post Office has very little cable property of its own, and was not particularly solicitous about what belonged to private people. But the Convention, to do it justice, was kept within reasonable bounds, and on the whole tried to do its best for all parties. What it lacked was knowledge of many of the practical issues involved; and also, as it turned out afterwards, of some of the local conditions which rendered their decisions nugatory. In so far as may be now possible to remedy these shortcomings the eminent and experienced men who have gone to Paris in the interests of the great cable corporations may be trusted to do all that can be done.

Whether they can undo some of the mischief already done remains to be seen. Nominally the Conference meets for the purpose of ratifying the stipulations of the 1884 Convention, each party to it having undertaken in the meanwhile to legislate in the sense agreed upon; that is to say, each Government promised to enact laws which would enforce by penalties in their respective countries the regulations agreed upon at Paris. Under some of these regulations, as was shown when the enacting measure was discussed in the Imperial Parliament, any owner or captain of a ship laying or repairing a cable in the proximity of other cables would have to run the risk of imprisonment for a period varying from three months to five years. Culpable negligence was a very elastic phrase; and it was felt to be so more especially in the well-known circumstance that new cables had been wilfully and recklessly laid across older cables, which could not be disturbed without "culpably" damaging the others. The culpability seemed to be altogether with those who ran the risk for the sake of shortening their journey or embarrassing their neighbour's property. It was felt also that the interpretation of this and other provisions of the Convention might depend very much on the country in which a case of negligence is tried. Many attempts were made in the House of Lords—a full report of whose proceedings will be found in *The Electrician* for July 31st, 1885—to amend the English Act so as to make its pro-

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visions more consistent with ordinary usage and common fair play, and some useful modifications were actually introduced; but it was found impossible to make the Act at once satisfactory to English cable proprietors and conformable to the Articles of the Paris Convention.

It further appeared that in one important particular the English Government were powerless to carry out the spirit of the Paris Convention—or at least professed themselves powerless. A very sensible recommendation was formulated by the Delegates that the respective Governments should exercise some regulating influence over the landing of cables on their shores. The British Government when called upon to act up to this provision declined to do so, on the plea that in many localities the foreshore belonged to private individuals, whose rights could not be curtailed. The plea is ridiculous, for if it is good for anything it would cover the landing of a hostile army. The real objection was confessed by one official apologist when he declared that to interfere with the landing of fresh cables would be favouring the existing cables. But one chief object of the Convention is to "favour" them by regulating and protecting them; and you cannot do either if you permit indiscriminate cable laying. England's laxity in this respect is, in fact, at the root of the whole difficulty, so far as British waters are concerned and for a great way beyond them. On some extravagant application of the doctrine of free competition the Government allow all sorts of dangers and heartburnings to arise, and then calmly propose to inflict heavy penalties if any accident occur that can be construed as culpable. A provisional order ought to be sought for every new cable, just as is required for similar undertakings inland; and in that case, before granting it, suitable conditions would be imposed to prevent fresh complications. A suggestion in this sense was made in the House of Lords, but dismissed as unpopular. Our opinion is that any legislation for the protection of cables will remain ineffectual unless the duty of regulating them is frankly recognised.

CORRESPONDENCE.

OZONE AND OTHER GAS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In common with every reader of your journal with whom we are acquainted, we for some little time looked forward to the perusal of certain effusions appearing in your correspondence columns as a weekly recreation. It has, however, been suggested that the wearing threadbare of the one or two comic ideas may possibly indicate that these fearful and wondrous "facts" and "proofs" (?) are to be looked at in a serious light. The bare possibility of such an idea has struck consternation into many a manly breast, and we feel constrained to ask whether it may not be advisable to label such matter in the business-like way of the German papers "Humoristich ?"—Yours, &c. A AND B.

May 10, 1886.

SABINE *VERSUS* WHITE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I hope you will allow me to correct an error I made in my previous letter to you, and thereby do an act of justice to Mr. J. G. White in America.

In my previous letter I wrote as if the late Robert Sabine had preceded Mr. White in the same line of thought about the covering of electric wires; but in doing so I have erred. Mr. Sabine made two tables for currents from 5 to 90 and from 100 to 1,000 amperes for conductors of bright copper exposed to the air. These tables were first published on January 6, 1883, and reprinted on May 5 of the same year. At the end of the latter publication of these tables is appended this note: "When the conductor is covered with india rubber the rise of temperature will be about 25 per cent. less than the values indicated above." This note implies that to cover a wire carrying a current of electricity is a means whereby the wire may be kept cool, and as this result is in accordance with the results of Mr. White's experiments, I too readily adopted the conclusion that Mr. Sabine had made experiments which led him to write the above note; but on a more careful examination of his published writings I find that the note is a contradiction to all his other writings, and there is no evidence whatever in them to show that he had made experiments with covered and uncovered wires, such as Mr. White has made. That Mr. Sabine, prior to his making out the said tables, did not make experiments on covered and uncovered wires is manifest from his own declaration that the tables "are only tentative, and do not pretend to be strictly exact." In Mr. Sabine's remarks which accompany the first publication of the tables on 6th January, 1883, he enters into theoretical statements about the effect of covering wires, and sums up his opinion in these words:—"The elevation of the temperature of any [electric light] lead is proportional to the obstruction which the insulator offers to the escape of the heat generated in it." Now, this opinion of Mr. Sabine is overturned and shown to be untrue by the results of Mr. White's new experiments, as published by Prof. W. A. Anthony in an American contemporary. As these experiments are not only interesting, but of importance, I send you an extract of Prof. Anthony's remarks on them, in the hope that you may be able to find a corner for them.—Yours, &c.,

8, Merchiston-park, Edinburgh, JAMES JOHNSTONE.
10th May, 1886.

[EXTRACT.]

Prof. W. A. Anthony, writing about experiments made by Mr. G. White, at the Physical Laboratory of the Cornell University, says: "Wires in length of about 100ft., half covered and half naked, of various sizes and styles of insulation, were obtained from the manufacturers. One of these wires being strung up in such a way that the covered and naked portions were equally exposed, a current increasing in strength from one whose heating effect was inappreciable to the largest the wire would bear was sent through the entire length of it, and the resistances of the two portions measured while the current was passing. To provide for the measurement of the resistances the wire was made to form one branch of a Wheatstone balance, the other branches of which were so arranged as not to be heated by the currents that flowed through them. In *every case* the resistance of the naked wire increased much more rapidly than that of the covered, and, in general, the thicker the insulation, the less the increase in resistance. In the case of a 'Clark' insulation, for instance, where the wire was 65 mils., and the covering 285 mils. in diameter, the increase in resistance due to heating by the current was, I think, about three times as much for the naked as for the covered portion. I was myself surprised to find that the effect of the covering to keep the wire cool was the general and not the exceptional effect. In what respect a covered wire differs from a covered steam pipe will appear when the complete account of this investigation is published."

ELECTRICITY *VERSUS* HEAT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I venture to think that Mr. Johnstone has got on some utterly wrong tack in his studies; but to begin a controversy with him on the subject of conduction and radiation of heat and on conservation of energy would be a task which, I think, no one will undertake. He will find the explanation of his newest puzzle given by the late Mr. Robert Sabine himself (whom he quotes), also more fully by Prof. G. Forbes, York Meeting of the British Association; by Sir W. Thomson, Royal Society, Edinburgh, paper on the "Effect of Clothing;" and by Mr. J. T. Bottomley, Royal Society *Proceedings*, June, 1884. I enclose my card.—Yours, &c., A READER.

May 8, 1884.

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THE STEAM ENGINE INDICATOR.—XVI.*

BY AMICE.

Compound engines are variously arranged with respect to the relative positions of the cylinders. The most usual arrangements are those having two cylinders, one behind the other, tandem fashion, with one piston rod running through both pistons; and those in which the two cylinders are placed side by side, and have their pistons connected, through the medium of connecting rods, to cranks at right angles, or nearly so. A third arrangement consists of two cylinders placed side by side, the pistons always moving in opposite directions through their connection with cranks at opposite or nearly opposite centres. There are other arrangements of the two-cylinder compound engine; but they are not now in such extensive use. The three arrangements above mentioned are typically shown by the diagrams, Figs. 43, 44, and 45. The tandem engine

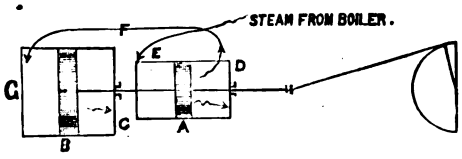

Fig. 43.

is shown by Fig. 43. In this A is the high-pressure cylinder, and B the low pressure. Steam alternately enters at either end of the cylinder A, and is cut off at some part of the stroke of its piston, as at half stroke. Near the end of its stroke exhaust commences, the exhaust steam passing into the cylinder B. In the diagram (Fig. 43), steam from the boiler is entering at the back end of the high-pressure cylinder at E, and exhaust from the front end D of the same cylinder is passing,

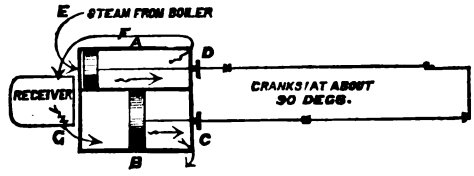

Fig. 44.

as shown by the arrow F, into the back end of the low-pressure cylinder B. An expansion valve must be used for the high-pressure cylinder, but need not be for the low. The pistons are shown as at half stroke, and the crank is is therefore not quite vertical. The rates and direction of movement of the two pistons in this arrangement are, of course, the same; and while the advantages connected with the performance of the expansion in two cylinders are

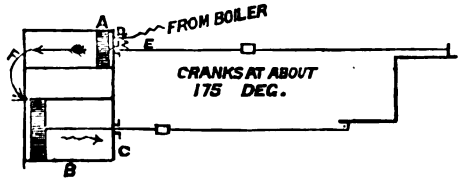

Fig. 45.

obtained, it is a disadvantage, from a mechanical point of view, that the maximum pressure is on both pistons at the same time in the same direction, and therefore also on the crank. The turning moment is subject to the same extremes as with a single cylinder engine, the maximum load on the two pistons acting precisely as though the whole work were done by one piston. It will be observed that the back pressure on the high-pressure piston is always the same as the forward pressure on the low-pressure piston, with the exception of the slight loss due to friction in the steam ports or passages. It may further be observed that the temperature in the high-pressure cylinder will have nearly as great a range as with the single cylinder, or simple expansive engine; but the range is spread over two strokes instead of one. If we follow the steam through one revolution, by the aid of Fig. 43, this will be seen. As shown in the diagram the out stroke is being made as shown by the arrows placed inside both the cylinders. The steam passing from D to G will fall in pressure in accordance with the increase in volume, and the temperature with it, and as the high-pressure cylinder is in communication with the low-pressure throughout the whole of one stroke—that shown as being made—the temperature of the communicating vapour may fall to that of the low-pressure cylinder at the end of its stroke. The cylinder walls are prevented from falling to this temperature by the high-pressure steam the other side of the piston, but, of course, at the expense of the heat of that steam. Thus, with the tandem compound engine without a receiver and cut off valve, the effect of communication with the low-pressure cylinder when the steam has reached its minimum temperature is not avoided, and one of the chief objects of the compound system is only partly realised. On the other hand, the back pressure on the high-pressure piston falls to that of the lowest pressure in the low-pressure cylinder.

In the arrangement shown by Fig. 44 the range of temperature in the high pressure is not so great, and is never greater than that due to the difference between the maximum temperature in the two cylinders. This is effected by causing the exhaust from the high-pressure cylinder to pass into a receiver, as shown by the arrow from D. The temperature of the high-pressure cylinder will thus be not less at any time than that in the receiver. The back pressure in A is, also, never less than that in the receiver. The low-pressure cylinder B receives its steam from the receiver, and is fitted with an expansion valve, or a valve with some lap, by which steam is cut off at less than full stroke, and communication between the two cylinders closed. The difference between the possible efficiency of this form of engine and that shown in Fig. 43 is not necessarily very much, but the gain is decidedly in favour of the receiver arrangement shown in Fig. 44. Sometimes no special receiver is made, the communicating passage and low-pressure valve chest being of sufficient capacity for the purpose. As will be seen from the diagram, the pistons are connected to cranks, which are placed on the two arms of a right angle, or at about 90 degrees apart, so that when one piston is at the end of its stroke the other is nearly at mid-stroke. The position of the cranks has some effect on the form of the indicator diagram, and as will be seen hereafter, an expansion valve is necessary for both cylinders. The action of the engine is the same as though it consisted of two distinct engines, the one supplied direct from the boiler, and the other from the receiver, the latter acting to a considerable extent in making the back pressure in the small cylinder more regular than in the arrangement shown in Fig. 43. The low-pressure cylinder may exhaust into a condenser, the engine then acting as though it comprised a high-pressure non-condensing engine and a low-pressure condensing engine.

In Fig. 45 another arrangement of compound engine is shown, in which the cylinders are placed side by side, in some cases with a receiver between, and in some—as is also the case with the arrangement shown by Fig. 44—with no more receiver than is provided by the passage from the high to the low-pressure cylinder and the valve chest of the latter. The cranks are sometimes placed opposite each other or at 180 deg. apart; but in other engines the cranks are placed a few degrees less than this apart, say at 170 deg., so that the engine may be started from any position, the efficient action of the steam not being at all affected. The admission and exhaust of the steam from the cylinders are the same as in the tandem engine (Fig. 43), and, although the pistons travel in opposite directions, the rotative effort on the crank is the same, and the indicator diagram shows the action of the steam to be the same.

These diagrams (Figs. 43, 44, and 45) are sufficient to explain the principle of the compound engine, although other arrangements have been made, but are not general. We may, however, describe some by reference to Figs. 46, 47, and 48.

Fig. 46 shows an arrangement which is classed amongst compound engines, but is a single-cylinder engine in which the expansion is performed in two stages. A hollow piston

* For Art. 15, see *The Electrician*, 12th February, 1886.

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rod or trunk piston rod is employed, and the connecting rod pivoted therein, as shown. The trunk occupies a large space, and thus reduces the area of the cylinder at the front end to a determinate amount less than that of the back end, and thus makes it suitable for the high-pressure steam. This steam from the boiler is admitted to A, and being cut off at, say, half stroke, is correspondingly expanded. At the end of the stroke the steam passes as indicated by the arrow F to the end B of the cylinder, which not being occupied by the trunk is much larger in area, and serves as a low-pressure cylinder in which the steam already partly expanded, is expanded to the lowest pressure desired. The action of the steam is the same as that in the arrangement shown at Fig. 45, and the indicator diagram the same. It is an arrangement in which the temperature in the cylinder varies between the same extreme as in a simple engine, but, as in Fig. 43, the variation is

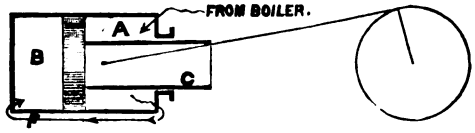

Fig. 46.

spread over two strokes instead of one, and to this extent the arrangement is supposed to secure a possible economy not thought attainable by the simple engine. The use of the trunk is not, however, advisable, as it not only provides a considerable condensing medium in consequence of its being half its time out of the cylinder, but the friction of so large a gland as is necessary to make it tight, is heavy.

Fig. 47 shows an arrangement in which the steam from the

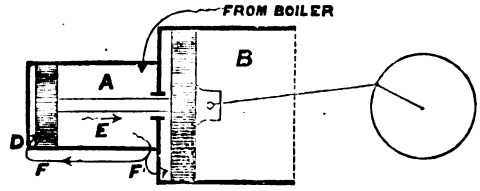

Fig. 47.

boiler enters the front end of the high-pressure cylinder, as shown by the arrow. When the stroke is completed the steam is exhausted simultaneously from the front end of the cylinder A into the back ends of both A and B cylinders, as shown by the arrows F and F'. The high-pressure piston thus performs the stroke, in the direction of the arrow E, in equilibrium, the pressure on both sides of it and on the low-pressure piston being the same, the low-pressure piston

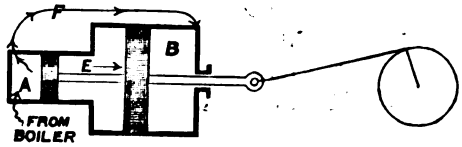

Fig. 48.

performing the work by virtue of its greater area. The front face of the piston in B is open to the atmosphere. It will thus be seen that the high-pressure steam from the boiler does not work against any back pressure, but the low-pressure piston has the atmosphere against it. If the end of the cylinder B were closed, as indicated by the dotted line, the tandem engine of Fig. 43 would be repeated.

Another form of engine is shown at Fig. 48. In this the steam from the boiler enters at A, drives the piston in the direction shown by the arrow E, and when it arrives at the end of the stroke, the steam is exhausted or passes from A to B, as shown by the arrow F. In the arrangements shown at Figs. 46 and 47 only one slide valve, double ported, is required, and it is possible to do with only one for Fig 48.

In our next article we shall give typical indicator diagrams from engines of the several arrangements described.

(To be continued.)

IMPROVEMENTS IN MICROPHONES.

It is stated in the April number of the *Elek. Zeit.* that a microphone with only one carbon must only have a very weak current sent through it, since otherwise the burning of the carbon makes a disturbing noise in the telephone. The amplitude of swing of the microphone plate, and therewith the change of resistance in the carbon contact, must be much smaller than with microphones with several carbons, since the already weak current cannot be subject to much variation without being broken altogether, which produces a very bad effect. In fact, a small arc is formed between the carbons, and a hissing sound like that of the arc-lamp is heard. One cannot increase the sound by speaking louder without losing distinctness in the receiver. The more carbon contact-pieces are inserted in parallel arc the smaller the resistance becomes, and the greater the current may be without a development of heat taking place at the contacts. Fig. 1 shows the arrangement

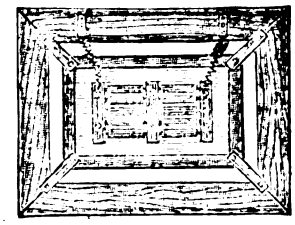

Fig. 1.

Fig. 2.

in the Ader microphone. The plate which bears the carbons is fixed to a frame by four straps of india rubber. This leaves an open space round the plate, and prevents the drum-like sound of a closed box. Fig. 2 shows how the carbons underneath have small pieces of flattened wire to prevent the carbons from twisting round as they vibrate, which would give a rattling sound.

POLLAK'S CELL.

This element consists of a glass vessel, at the bottom of which there is a zinc cylinder 30mm. high, and having a diameter of 75mm. This latter forms one of the electrodes. The other electrode is at the upper end of the glass vessel, and consists of a cylindrical carbon, 80mm. high and 95mm. in diameter, which combines great porosity with good conduc-

Fig. 1.

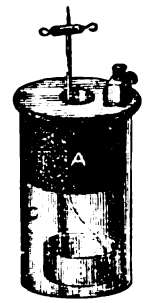

Fig. 2.

tivity, and on whose lower end there is a deposit of electrolytic copper. After both electrodes have been placed in the glass, sal-ammoniac or common salt is sprinkled in, and the cell is then filled with water, which should rise about three or four centimetres above the lower edge of the carbon. The copper form compounds with the sal-ammoniac, which colours the liquid blue. The nascent hydrogen, from the action on the zinc, which is liberated at the copper, decomposes the copper compounds, which are again formed by the agency of the carbon. Thus the element regenerates itself by means of the air in the carbon. Since gravitation plays a con-

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siderable part in the action, it must be allowed to stand without too much shaking. This element possesses the following recommendations :—It is constant, the materials used in it are cheap, and it requires little looking after.

Two types of cell are made by M. Wehr. The type A is 16½ centimetres high and 11½ centimetres in diameter. Type B is 18 centimetres high and 16 in diameter. The E.M.F. of the cell is 1·3 per volt, with a resistance of from 0·5 to 0·8 ozones. The charge required for a similar size is 200 grammes of sal-ammoniac, for the larger 250 grammes. Figure 1 shows the the cell generally used for telegraphic purposes, A being the cylinder of specially-prepared carbon. B is a cylindrical ring of zinc, carrying an insulated conductor to the binding screw, as shown. Fig. 2 shows the arrangement when the work is more intermittent. The carbon in this case is not covered at the lower part by electrolytical copper, but is said to be impregnated with certain salt, of which the composition has not yet been divulged. B shows the zinc ring, and in both cases C shows the saturated solution.

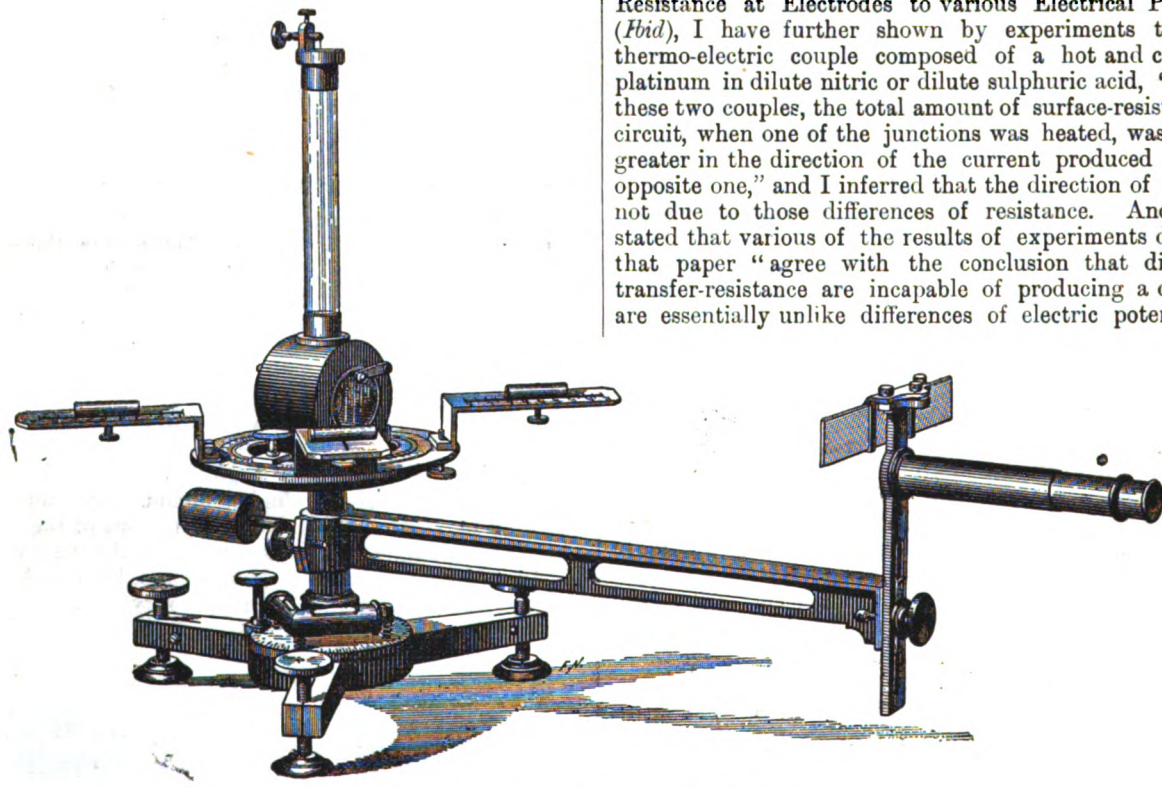
KOHLRAUSCH'S VARIOMETER.

Prof. Kohlrausch's variometer, of which the accompanying is an illustration, as it is manufactured by the firm of Hartmann and Braun, of Bockenheim, Frankfurt, is intended to furnish the physicist and electrician with a handy, cheap, and portable means of estimating variations in the earth's magnetic field ; a determination which, although obviously required for accuracy in many observations, has hitherto only been obtainable at a few large and well-equipped magnetic observatories. It consists of a simple unifilar magnetometer, the magnet of which is a circular disc of steel polished to a flat surface on both sides. It is enclosed in a heavy copper damping box of electrolytically deposited copper, of which material, to prevent local influence, the whole apparatus is constructed. Its special character consists in the fact that instead of a single deflecting magnet there are four, two fixed radially and two tangentially on a cruciform platform, which moves freely round the magnetometer.

A radial arm of some length carries a small milk glass scale, and a little reading telescope in which the image of the inverted graduations of the scale are seen in their correct position.

The small platforms supporting the four deflectors are also graduated, so that an artificial field of any given character can be reproduced, and the variations of the earth's horizontal intensity modified so as to be clearly perceptible in the telescope.

This handy little instrument should be in many physical laboratories besides the great observatories.



Kohlrausch's Magnetical-Intensity-Variometer.

ON "RESISTANCE" AT THE SURFACES OF ELECTRODES IN ELECTROLYTIC CELLS.*

BY G. GORE, LL.D., F.R.S.

In a former paper on "Evidence Respecting the Reality of Transfer-Resistance in Electrolytic Cells" (*Proc.* Birm. Phil. Soc., 1886 ; and *Phil. Mag.*, Feb., 1886, Vol. XXI.) I have shown that the passage of an electric current into or out of an electrode of sheet-platinum by means of dilute nitric or dilute sulphuric acid sets free at the surface of contact of the metal and electrolyte an amount of heat which cannot apparently be accounted for by any other cause than that of an obstacle of some kind to the passage of the current at those surfaces.

And in another paper, "On the Relations of Surface-Resistance at Electrodes to various Electrical Phenomena" (*Ibid*), I have further shown by experiments that with a thermo-electric couple composed of a hot and cold sheet of platinum in dilute nitric or dilute sulphuric acid, "in each of these two couples, the total amount of surface-resistance in the circuit, when one of the junctions was heated, was very much greater in the direction of the current produced than in the opposite one," and I inferred that the direction of current was not due to those differences of resistance. And I further stated that various of the results of experiments described in that paper "agree with the conclusion that differences of transfer-resistance are incapable of producing a current, and are essentially unlike differences of electric potential ;" also, "that heat decreases such resistance whilst increasing contact potential in various metal-electrolyte thermo-electric couples."

Lest it may still be supposed that the phenomena to which I have ventured to apply the term "transfer-resistance" are not really of the nature of "resistance," but are effects due to polarisation, some kind of counter electromotive force, or other form of opposing difference of electric potential, I have further examined, by means of the following experiments, the question whether the phenomenon I have found can exist independently of such difference.

A single conclusive adverse fact is sufficient to upset the most fixed theory ; if the phenomena termed "transfer-resistance" are really due to some form of opposing difference of electric potential, they ought to disappear wherever such difference is absent.

*Read before the Birmingham Philosophical Society, February 11th, 1886.

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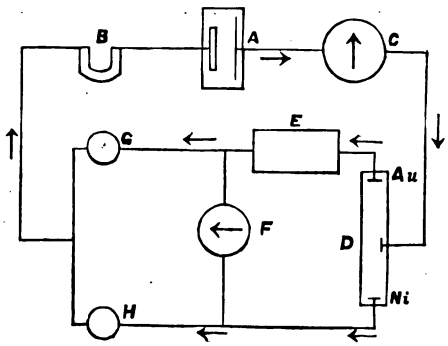
I have tested this point in the following manner:—By the aid of some tables of "Chemico-electric relations of metals in solutions of solts of potassium" (*Proc.* Roy. Soc. 1877, No. 200), and in another on "Some relations of heat," &c. (*Ibid.* 1884, No. 233), I selected cases in which two different metals in an electrolyte produced no voltaic current, and examined those combinations of metals and liquid for any differences of "surface-resistance."

I nearly filled a glass trough, 10·0 cm. long, 2·5 cm. wide, and 3·0 cm. deep, with a solution consisting of about 3 grammes of potassic cyanide (of 92·1 per cent.), and 100 cc. of water. In this solution was immersed, near the opposite ends of the trough, at 8·0 cm. apart, a sheet of nickel and one of pure gold, each being 1·0 × 1·0 cm., not varnished on the back, and connected with a graded dead beat Desprez-d'Arsonval galvanometer (see *Nature*, Vol. XXXI., p. 86), having a resistance of about 150 ohms, and I altered the strength of the liquid until all signs of difference of potential ceased. (The sensitiveness of the galvanometer was very largely increased by substituting for the suspending and connecting wires of silver above and below the movable coil fibres of silk, and making the connections with the coil by means of spirals 3·0 mm. diameter of platinum wire of about ·064 mm. thickness, enclosing the fibres. The instrument was then much more sensitive than an ordinary astatic galvanometer of 100 ohms resistance.)

To test for any difference of "surface-resistance" at the two metals, an electrode of nickel 2·0 × 1·0 cm. was placed in the electrolyte at exactly mid-distance between the end plates, and the following arrangement employed:—



A.—Battery of six pairs of zinc and platinum in dilute sulphuric acid. B.—Regulator of current (see *Proc.* Birm. Phil. Soc., Vol. IV., p. 422. *The Electrician*, 1885, Vol. XV., p. 196.) C.—D'Arsonval galvanometer. D.—Electrolytic trough. E.—Box of resistance-coils = 2,000 ohms. F.—Astatic galvanometer, resistance = 2 ohms. G. H.—Two resistance-coils of 5 ohms each.

The cyanide solution was at 9° C., and the total strength of current employed was = ·00058 ampere, or ·00029 to each end plate. The middle electrode was of nickel. The total current was passed in either direction according to whether the two metals were used as anodes or as cathodes, the bridge galvanometer F being brought to zeroby varying the resistance in E.

When the two end plates were used as anodes, 43 ohms required to be added on the side of the gold plate to restore the balance; and when they were employed as cathodes, 280 ohms had to be added on that side to restore it. The amounts, therefore, of total "surface-resistance" at the gold and nickel plates were in each case very unequal, that of the nickel one being the largest.

As the liquid was not stirred, the "surface-resistance" at each of the two plates included not only what I have termed "transfer-resistance," but also any opposing influence due to polarisation developed by the current. As, however, the reverse current, produced by first connecting the gold and nickel plates with the battery for a time equalling that of duration of the experiment, and then instantly switching them to a galvanometer, was less than one-hundredth the strength of half the total current employed in ascertaining the inequality of "resistance," the opposing effect due to polarisation must have been exceedingly small, and was equal at the two plates. I have already shown in a large variety and number of cases, described in an extensive research, communicated to the Royal Society, March 2nd, 1885, that the "resistance" still exists and varies greatly in amount in different cases, when polarisation is nearly or entirely prevented by employing and rapidly stirring a suitable electrolyte. It may also be remarked that the amount of "resistance" is not directly proportional to that of polarisation, for whilst the opposing force of the latter increases with increased strength of current, "transfer-resistance" decreases.

A second solution, composed of 7·0 grammes of potassic chloride, ·05 gramme of potassic cyanide (of 92·1 per cent.), and 80 cc. of water at 8° C., was tested with plates of gold and iron in a similar manner. The plates were each 1·0 × 1·0 cm., about 9·0 cm. asunder, and not varnished on their backs; the gold was very faintly positive, and this appeared on stirring the liquid. The total strength of current employed was ·0014 ampere, or ·0007 to each plate. The middle plate was of iron. With the two metals as anodes, the iron offered 1,230 ohms less, and as cathodes 26·0 ohms less resistance than the gold.

And with plates of nickel and copper 1·0 × 1·0 cm., 9·0 cm. apart, and varnished on their backs, in a third solution, composed of 1·89 grammes of potassic bromide dissolved in 100 cc. of water at 8° C., the potentials were equal. The strength of current employed was ·00058 ampere, or ·00029 to each metal. The middle plate was of copper. With the two metals as anodes, the nickel offered 650 ohms greater, and, as cathodes, 210 ohms less than the copper.

We know that the contact of two pieces of the same metal with an electrolyte of uniform temperature produces no difference of potential. I therefore took two electrodes of sheet platinum, varnished on their backs, one being 1·0 × 1·0 cm., and the other 2·0 × 5·0 cm., and 8·0 cm. apart, in the solution of potassic bromide at 8° C.; no current was produced. I measured their amounts of "surface-resistance" in the same manner, by means of a middle plate of platinum, and a total current of ·00058 ampere. As anodes, the "resistance" of the large one was 140 ohms less, and, as cathodes, 23 ohms less than that of the small one.

And in another similar experiment with plates of copper, one being 1·0 × 1·0 cm., and the other 2·0 × 5·0 cm., 8·0 cm. apart, and varnished on their backs, with a middle plate of copper, in a solution composed of 1·0 gramme of glacial phosphoric acid and 10·0 cc. of water at 8° C. As anodes, the "resistance" at the surface of the large one was 50 ohms less, and as cathodes 249 ohms less than that at the small one.

In the first three of these combinations, difference of "surface-resistance" was obtained by employing plates of different kinds of metal, and in the two last by using ones of different sizes. I have already stated (*Proc.* Roy. Soc., 1885, No. 236, p. 209) "that this resistance varies largely in amount with different metals in the same solution;" also, that "the usual effect of diminishing the density of current alone, by enlarging one electrode only, was to diminish the resistance at that electrode."

The results of each of these ten experiments show that the influence which opposes the current at the surfaces of metallic electrodes in electrolytes exists independently of counter-electromotive force, polarisation, and all other forms of electric potential, and is therefore a distinct phenomenon, and cannot be due to those causes.

The magnitudes of "surface-resistance" at each plate of different metal in the first three liquids were also separately measured, by means of an ordinary method with a condenser. The two end plates were immersed, 4·0 cm. apart, in the liquid in a glass beaker, the battery, regulator, D'Arsonval galvanometer, a coil of 200 ohms resistance, and a closed connecting key being in the circuit. A condenser of ·33 microfarad capacity was then connected through a Thomson reflecting galvanometer of 3,040 ohms resistance and a key, with the electrolyte close to one of the plates by means of a wire of the same metal as one of the electrodes, and with the wire circuit near that electrode, and the deflection noted. After discharging the condenser a second deflection was obtained in a similar manner, by means of the potentials on each side of the other plate, and a third by means of those at the

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two ends of the coil, and the "resistances" calculated from the results.

With the gold and nickel plates in the solution of potassic cyanide at 8° C., and a strength of current = ·00029 ampere, the "resistances" were :—

	As Anode.	As Cathode.
Gold	114 ohms	1,044 ohms.
Nickel	143 „	801 „

With the gold and iron in the mixture of potassic chloride and cyanide at 8° C., and a strength of current = ·0007 ampere, the "resistances" were :—

	As Anode.	As Cathode.
Gold	1136 ohms	768 ohms.
Iron	56 „	360 „

And with nickel and copper in the solution of potassic bromide at 8° C., and a current of ·00029 ampere, the "resistances" were :—

	As Anode.	As Cathode.
Nickel	639 ohms.	1565 ohms.
Copper	130 „	1565 „

The results obtained by this method agree substantially with those obtained by the previous one; there are, however, some considerable discrepancies in the amounts. It need hardly be remarked that in such experiments it is very difficult to obtain perfectly concordant quantitative results by two such different methods, and that it would not be reasonable to expect them. The results uniformly confirm the conclusion that "surface-resistance" may exist independently of all difference of electric-potential.

Equality of voltaic potential, attended by more or less difference of "surface-resistance," may be obtained by a variety of arrangements; and a large number of additional instances might be selected, in which the potentials are equal, whilst the "resistances" are unequal. The ones chosen were preferred because they were convenient and comparatively manageable. Cases of equality of "resistance" accompanying difference of potential might probably also be found.

Is the phenomenon I have detected really of the nature of ordinary electric conduction resistance? If it is, its characters will agree with the most essential ones of that influence. It agrees in several important points with ordinary conduction resistance; first, it is not able to produce a current; second, it is usually small with those liquids in which ordinary resistance is small; and, third, it is considerably reduced in liquids by rise of temperature (*see* "Relations of Surface-resistance at Electrodes," *Phil. Mag.*, Vol. XXI., Feb. 1886). It differs, however, from conduction resistance in the less important circumstance that it varies in amount with the strength and density of the current; with a given electrolyte it is also usually much larger in amount than the ordinary conduction resistance of a short section of that liquid; this appears consistent with the difference of conditions.

From these various fundamental truths respecting it, "transfer-resistance" is a retarding influence essentially similar to ordinary conduction-resistance, but modified, increased in amount, and rendered more complex by taking place at the surfaces of mutual contact of two heterogeneous bodies instead of in the mass of a homogeneous substance; but whether it ought to be designated by some other term than the one I have found it convenient to employ is a question not yet settled. It is my intention, if I am not prevented, to further investigate the subject.

As the magnitude of this "resistance" to that of the mass-resistance in a given electrolytic or voltaic cell is usually large, especially with non-corroded metals, it performs an important part in the action of voltaic batteries and electrolytic cells. One important practical application of the fact that "transfer-resistance" is usually diminished by enlarging the electrodes, has been made in the electro-metallurgical purification of copper on the large scale, where a great saving has been effected by arranging the depositing vats in "multiple series." I have also shown (*Phil. Mag.*, Vol. XXI., 1886, p. 150) that in consequence of diminution of "transfer-resistance" by rise of temperature, with a voltaic element composed of zinc and platinum in dilute sulphuric acid, "the electromotive force was increased about 8·38 per cent., and the strength of current 220 per cent., or to 3·2 times its original amount, by raising the temperature of the platinum negative plate 81·0C. degrees."

EXPERIMENTS WITH OIL AS AN INSULATOR.

BY H. C. FREMPT.

The oil used to insulate the underground wires running into the telephone exchange, at the corner of Broadway and Spring street, New York, is heavier than water. Take two cotton-covered wires which have been boiled in that oil, draw them through glass tubes, twist the ends together, and place them in an ordinary glass battery jar. Fill the jar half full of oil, after which water may be carefully poured into the jar and it will remain above the oil. Attaching the poles of a battery to each of these wires, as shown above the glass tubes, no current will be observed as passing from one wire to the other. See Fig. 1.

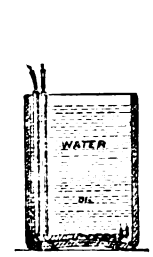

Fig. 1.

Fig. 2.

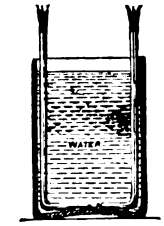

Fig. 3.

Take a piece of lead pipe containing a cable of cotton-covered wires insulated with the same oil in a fluid condition, and cut a hole in the lead an eighth of an inch in diameter, as shown at the point *a*, Fig. 2. The oil being viscous will ooze out slowly. Place the cable in a jar as shown, and fill the jar with water, the oil will continue to flow till an equilibrium is established, but no current can be passed from one wire to the other or from either wire to the lead pipe. Now, if instead of oil we use in this experiment paraffin, pitch, or resin, the insulation immediately fails.

Six years since there was a lead-covered cable insulated with oil, armoured and laid across the Delaware river. The cable contained 50 conductors, not one of which has failed. The cost of this cable of 50 conductors was no more than that of an ordinary gutta-percha insulated cable of five conductors. The gutta-percha insulated cable across the Delaware during this period have been continually subject to mishaps. Many of the conductors have been injured by lightning, although protected by lightning arresters. When the gutta-percha insulation is punctured by atmospheric electricity, it leaves a hole in the insulation in which water enters, by which the current passes to earth. The cable has to be under-run, the leak found, and the hole sealed up; but a hole cannot be made in a liquid. Many of the small streams flowing into the Delaware are bridged with draws to let through passing vessels. Beneath these draws have been placed lead cables, which in some instances have been caught and kinked, as shown in Fig. 3. The strain upon these kinks has been such that if the wire had been insulated with gutta percha or india rubber the insulation would have been destroyed. The combination of lead, cotton, and wire is much less liable to injury from a strain of this nature than the combination of india rubber or gutta percha with the wire as insulated in the usual form.

ELECTRIC LIGHT FOR MADRID.

In continuation of our remarks last week upon the proposed substitution of the electric light for gas in Madrid, we now learn from Spanish advices that the installation is to be carried out by Messrs. Edison, of New York, though no formal contract appears to have been made with the municipal authorities. The *Comercio Español* states that Mr. Perez Valdivieso, Messrs. Edison's representative in Madrid, asked in the first place, as a preliminary, if it were possible to establish a central station of some 300 square metres within about half a mile of the Puerta del Sol. This has been pro-

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vided. In the second place he asked as to the probability of many users of the light. Nothing positive was stated on this point, but considering the unanimity with which the decision to discontinue the use of gas was arrived at, and the cheapness of the electric light, it was submitted the customers would be numerous.

The third question was with regard to the installation and laying of wires. It was pointed out, on counsel's authority, that the conditions of the existing Gas Company contain nothing to prevent the Ayuntamiento making fresh arrangements for replacing the light by any well-known system, having been in active operation for at least three years, either in Spain or abroad. The Alcalde, or Mayor, has, on this declaration, promised to do what he can to further the wishes of the trading community; but he has expressly stated very clearly that Messrs. Edison must not expect to receive any privilege from the municipality. Privileges, he says, have already cost the ratepayers too much for any fresh ones to be granted, however beneficial they may appear. It is possible rather that the Ayuntamiento may impose a municipal-tax upon the company. As a result of the various interviews, it is stated that the Edison Company has resolved to immediately push forward the installation on a large scale. Cable advices from New York report that six engineers are leaving for Madrid with the necessary funds and material.

THE SPANISH TARIFF AND IMPORTS OF ELECTRICAL APPLIANCES.

The Spanish Customs authorities in Madrid have just given their decision in an appeal against the imposition of somewhat heavy duties upon the import of galvanised iron fasteners for the support of telegraphic insulators. Last year a large consignment of 4,650 kilogrames of these fasteners was made to Santander, and the clearing agent attempted to pass them through the Custom House under section 27 of the Spanish tariff, which runs as follows:—"Wrought iron and steel in bars of any shape, in sheets up to six millim. thickness; axles, tyres, plates, and springs for carriages; and iron hoops—13 pesetas per 100 kilos. for non-treaty nations, and 8 pesetas 65 cents. for treaty nations." The Custom House officials, however, levied duties under section 30, the terms of which are as follow:—"Iron nails and screws although with brass heads—20 pesetas for non-treaty, and 14 pesetas 85 cents for treaty nations. The consignee petitioned the central authorities against this charge, and submitted that section 27 of the tariff ought to be amended so as to include imports of the goods in question. The request has been refused, and the Customs journal, *El Eco de las Adnanas*, has published a Royal Order to the effect that iron screws or nails for supporting telegraphic insulators shall pay duty under section 30 of the tariff. Shipments from this country will therefore have to pay an import duty of about 16s. per 100 kilos., as compared with a charge of about 11s. 10d. per 100 kilos. upon similar goods imported from France or Belgium. Should the arrangement for a *modus vivendi* just arrived at be ratified by the Cortes—and there is little doubt that it will be opposed by the English Parliament—English goods will thenceforward enter Spain on the same terms as those of our Continental competitors. It is to be hoped that the treaty may soon come into operation, as the introduction of electric lighting and of electric appliances generally is making rapid progress both in Madrid and in the Spanish provinces.

ELECTRIC LIGHTING AT EDINBURGH EXHIBITION.

The electric lighting is one of the most important features of the Exhibition, and should render it even a greater attraction after dark than during the day. The installations form the largest thing in the way of electric lighting that has ever been attempted. There can be no doubt that this will draw to the Exhibition a large body of practical electricians, who will have the opportunity of criticising the different systems of lighting in actual work. Power for driving the dynamos is obtained from engines supplied by Messrs. Robey and Co., of Lincoln, Messrs. Adamson and Co., of Manchester, and Messrs. Marshall and Sons, of Gainsbro.'

Perhaps the most attractive display is in the centre corridor, which is entirely lighted by 1,500 incandescent lamps of 20 candle-power each. The lights are controlled by 26 circuits of three girders on each, making a total of 78 girders. The leads are run in such a way that the lamps affixed to each alternate girder may be put out at the same time. In connection with this the switch-board is arranged so that in case of any failure of a dynamo another can be switched in without any change perceptible to the visitors. There are six dynamos and three vertical engines for this section, also two dynamos and one spare engine in case of a break down.

The outside lighting is arranged to be worked by two dynamos capable of running 1,200 lamps of 10 candle-power each. These lamps are supplied by the Edison-Swan Company, and have been coloured red, golden, and blue. There are but two circuits, and the lamps are hung from mast to mast in festoons.

Section C is lighted by thirty-two 3,000 candle-power Gülcher arc lamps, placed four in each court, and suspended by the company's improved raising and lowering counterbalance arrangement. Each arc lamp is worked by an independent switch, so that any number of lamps may be used as desired. The two reception rooms and many of the exhibitors' stalls are lighted by incandescent lamps, suspended either by pendants or fittings as found most suitable, the current being taken from the same dynamo as the arc lamps.

The illumination of the grounds is by thirty-two 2,000 candle-power Gülcher arc lamps, constructed for outdoor work, fitted with clear glass globes and white reflectors. The lamps are suspended in groups of four arranged on high poles, each of which is fitted with a special head gear for carrying the lamps, and to enable them to be raised and lowered as required. Each arc lamp is fitted with a switch, which enables it to be burnt quite independently of the other lamps. The current for working the 64 arc lamps and incandescent lamps is generated by four No. 5 compound-wound Gülcher dynamos of the most improved type.

There is an electric railway in the grounds, which is being well patronised by the visitors.

The lighting arrangements are in the hands of Messrs. King, Brown, and Co., of the Rosebank Electric Works, Edinburgh (under the personal superintendence of the foreman electrician, Mr. Henry Lyon), who have also the arrangements for the electric railway; the Gülcher Electric Light and Power Company, of Battersea Foundry, S.W. (under the personal superintendence of Mr. E. Ingles); Mr. R. Miller, of Glasgow; the Anglo-American Brush Company, of Belvedere-road, Lambeth; and Messrs. J. D. F. Andrews and Co., of Woodside Works, Glasgow.

THE ELECTRIC LIGHTING ACT (1882) AMENDMENT (No. 3) BILL.

Petition against, and in favour of "The Electric Lighting Act, 1882," Amendment (No. 1) Bill by the Institution of Civil Engineers.

1. That in the year 1882 an Act of Parliament was passed to apply to all provisional orders or Acts relative to the distribution of electricity for lighting and other purposes.

2. By Section 27 of the said Act it was enacted that at the expiration of twenty-one years, or such shorter period as might be provided in the Special Act, and within six months after the expiration of every subsequent period of seven years, or such shorter period as might be provided in the Special Act, any local authority within whose jurisdiction the area of the undertaking, or any part thereof, was situated, might require the undertakers to sell their undertaking, or part thereof, upon the terms of paying the then value of all lands, buildings, works, materials, and plant suitable to and used for the purposes of their undertaking, and in the event of non-agreement the price was to be determined by arbitration; but the arbitrator was forbidden to allow any payment in respect of compulsory purchase, or of goodwill, or of any profits which may, or might have been, or be made from the undertaking or of any similar considerations.

3. That the effect of the foregoing conditions has been entirely to stop, during the four years since the Act has been passed, the application of private capital to the distribution of electricity from a central station to householders, manufacturers, shop keepers, and others desirous of receiving it as a source of illumination; it being impossible to find persons of means who would embark their capital in undertakings subjected to such conditions, conditions which must of necessity when enforced—as they would be if the undertaking were prosperous—return to the shareholders only a small portion of the capital which they had invested.

4. That your petitioners embrace among their members persons practising in every branch of civil engineering, which is defined in their charter to be the art of directing the great sources of power in nature for the use and convenience of man, thus including electrical engineering, and that they are desirous—in the interests of industry and of the growth of a new and useful application of science to the purposes of daily life—that electrical lighting should have a thoroughly full and fair trial.

5. There are now before your lordships' house three Bills, Numbers 1, 2, and 3, each of which purports to be an amendment of "The Electric Lighting Act of 1882."

6. Number 3 Bill, the one brought in by Lord Houghton, does not vary the Act of 1882, except by an extension of the time before the compulsory right of purchase would arise, from the twenty-one years of the Act of 1882 to thirty years, with a further period of twelve years should the local authority agree, and by the extension of the recurrent periods of option from seven years to ten years.

7. Your petitioners are convinced that such a measure would not cure the defects of the existing law, and would not be successful in attracting capital to an electric light undertaking, which must be essentially one of development. Unlike the case of the construction of a railway between two points, or of a canal between two points, or of the making of a dock, cases where the work is done as a whole and where the capital is needed, and is called up at once, an electric light undertaking is one wherein, at the outset, only a comparatively small portion of the capital can properly be utilised, and it would not be until after a lapse of years, when persons had been educated to use the electric light, and were willing, for the sake of its advantages, to discard the gas fittings for which they had already paid, and to incur the expense of electric light fittings, that there would be such a large or general use of electricity for lighting purposes as to need the expenditure of further capital.

8. That with such a clause as that proposed by No. 3 Bill—a clause which merely defers the time of compulsory purchase—it would be impossible to obtain this extra capital as needed, because even if, at first, persons would subscribe for a probable enjoyment of thirty years, no one would be found to embark money after the lapse of a few years when the term of enjoyment was so much shortened.

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9. No. 2 Bill ameliorates Section 27 to some extent, but the Bill (No. 1) now before your lordships' house proposes to repeal the Act of 1882 altogether, and to assimilate the legislation in respect of electric light undertakings to that legislation which of late years has prevailed in respect of gas undertakings, and has proved so beneficial to the public while yielding security of property to those who embark their capital. Bill No. 1 provides that the obligations upon the distributors of electricity shall be the same as those which are imposed upon gas undertakings, that dividends shall be regulated upon the sliding scale, by which there is a direct incentive to the undertakers to sell the commodity at the lowest possible price consistent with a profit, and, further, that all future capital shall be issued under an auction clause, thus ensuring that the consumers shall not be liable to pay any greater amount as dividend than is fairly demanded by the risk of the undertaking.

10. Your petitioners desire to point out that the new industry of electric lighting has been, by the Act of 1882, and would, by the Amended Bill, No. 3, if it were passed into law, be subject to burdens which render it impossible to give a mode of lighting that has so much to commend it a fair chance of development, and therefore prevent the establishment of an industry that would give householders and others an option as to the mode of lighting from an external source of supply, an option they do not now possess.

Your petitioners therefore humbly pray your lordships that the said Electric Lighting Act (1882) Amendment (No. 3) Bill may not be allowed to pass into law, but that the Electric Lighting Act (1882) Amendment (No. 1) may pass into law, and that this petition may be referred to the committee of your right honourable house, to whom those Bills have been referred, or that such other relief may be given to your petitioners in the premises as your lordships shall deem meet.

LEGAL.

Edison and Swan v. Woodhouse and Rawson.

This long-expected trial has at last commenced. The case came on on Monday, May 10, before Mr. Justice BUTT, sitting for Mr. Justice NORTH, in the Chancery Division of the High Court of Justice. We shall give but an abstract of the proceedings till what may be termed the summing up matters and the verdict, which we hope to give fully.

The plaintiff in this action are suing to restrain the infringement of three patents relating to incandescent electric lighting—a patent taken out by Mr. Edison in 1879, a patent taken out by Mr. Swan in 1880, and a more recent patent by Mr. Giningham.

Sir Richard Webster, Q.C., Mr. Aston, Q C., Mr. Moulton, Q.C., and Mr. T. Edward Dove appeared for the plaintiffs; the Solicitor-General (Sir Horace Davey, Q.C.), Mr. Charles, Q.C., and Mr. Murray for the defendants.

Sir RICHARD WEBSTER opened the case for the plaintiffs, and described in general terms the claims of Mr. Edison as being for the combustion of a filament of carbon inside a lamp or globe wholly of glass in an almost perfect vacuum, the carbon filament being fixed into the ends of platinum wire, which is passed through the glass hermetically sealed up. The advantage in the use of platinum is that its rate of expansion under heat is much the same as that of glass. A great feature in Mr. Edison's invention is the mode in which he produces a filament of carbon; that is to say, he carbonises a filament instead of doing what had been attempted before, paring down a carbon stick to the smallest possible size. Sir Richard Webster said that this was a thing which no one else had ever thought of, and it had made practical the use of a high resisting medium of very small superficial area for the purpose of incandescent lighting, and thus allowed the multiple arc system of transmitting the current, by which system alone a satisfactory mode of distribution has been able to be used. Mr. Edison made no claim for any particular mode of producing the extremely rare vacuum he requires. The production of such a vacuum would, of course, have been impossible but for the invention of the Sprengel air pump in 1873. Mr. Swan's claim is for an improved mode of obtaining a better vacuum, by which he gets rid of the air in the carbonised filament; and the third patent, that of Mr. Giningham, is for a very simple but efficient way of fixing the ends of the filament of carbon into the ends of the platinum wire. The latter are flattened out and rolled into tubes or sockets, and the ends of the filament, which is bent into a spiral or, in the more recent form, into a double twist, are kept in the sockets by the spring or electricity of the filament itself. The defence seems mainly rested on anticipation. The particulars of objection on this point are almost unprecedented in number, being no fewer than 75. Among the most important is a patent taken out by one King, as long ago as 1845, for an incandescent carbon electric light in a vacuum. The vacuum used was the Torricellian vacuum (the best known at the time), that is to say, in fact, the vacuum that exists at the top of a barometer. Among other anticipations set up were certain patents by Lane-Fox, in date slightly before the patent of Mr. Edison's that is being sued upon. Mr. Lane-Fox used platinum and iridium as the substance to be made incandescent, but it was suggested that carbon filaments were within his claim. Another most interesting illustration of the history of this kind of electric lighting in evidence was a lamp made by Mr. Swan, and exhibited by him at Newcastle, in which the illuminant was a thin rod of carbon. Mr. Swan seems to have had no idea of patenting that instrument.

Sir Frederick Bramwell, the first witness for the plaintiffs, was examined by Sir Richard Webster. He described his view of the nature of the inventions of the plaintiffs, and said he had gone through all the alleged anticipations, and in none of those could he find any anticipation of the merits claimed, and that, from his knowledge of the subject otherwise, he was able to say that the matters claimed were new.

He was cross-examined by Mr. CHARLES, Q.C., and his cross-examination was not concluded at the rising of the Court.

On Tuesday the cross-examination of Sir Frederick Bramwell was continued by Mr. Charles, Q.C.; he was re-examined by Mr. Aston, Q.C. Dr. Hopkinson, the plaintiffs' second witness, was then put in the box, and examined in chief by Sir Richard Webster, Q.C., and he was under cross-examination by Mr. Charles, Q.C., when the Court rose, which happened shortly before the proper time because, as if in comment on the proceedings, the Edison-Swan electric lamps, by which the court is lighted, were switched out. The great endeavour of the cross-examination as regards the Edison patent has been to show upon various specifications, relating chiefly to patents for arc lamps, and from other documents, that the process of getting charcoal filaments by carbonising the filaments was known in the year 1879. With regard to the Swan patent, the endeavour was to show that Mr. Edison had indicated previously the advantage and mode of superexhaustion of the air while raising the temperature of the enclosed carbon material; and with regard to the Giningham patent, to show from its very simplicity that the invention was known to everybody.

On Wednesday the Court was again occupied with the evidence of scientific witnesses on the part of the plaintiffs The cross-examination and re-examination of Dr. Hopkinson were completed; Dr. Fleming, Professor of Electrical Technology at University College, was examined by Mr. Aston, Q.C., cross-examined by the Solicitor-General, and re-examined by Mr. Moulton, Q.C. Mr. John Imray, the well-known patent agent and engineer, was then examined by Mr. Aston, Q.C., cross-examined by the Solicitor-General, and re-examined by Mr. Aston. Almost the whole of the evidence, as on the preceding day, was directed to questions of anticipation of the several inventions the subject of the action.

On Thursday the Court resumed the evidence of witnesses on the part of the plaintiffs, which took up the time of the Court until 1 o'clock. The evidence was chiefly directed, as on the previous day, to questions of anticipation of the various inventions.

The SOLICITOR-GENERAL, in opening the case for the defendants, proceeded to argue that no evidence had been elicited from the witnesses examined to show that the carbon filament of the defendants was made in the way described by Edison. This was particularly notable in the case of Sir Frederick Bramwell, who could not say that the filament was so made, and he (the Solicitor-General) contended therefore that there had been no infringement of the patents in question. He submitted that if his learned friend, Sir Richard Webster, had been able to produce such evidence he would have done so, but it had not been produced, and what was wanted in a case of this kind was proof as to facts, and not statements of opinion. He further contended that the use of carbon filaments was not by any means a new discovery. All that Edison did was to describe a method of using a carbon filament in a way which would make it much more successful in practice—that was to say, by merely using a finer filament than had been adopted previously. He proceeded to describe the antecedent publications of King in 1845, who used a carbon conductor; of Roberts, who also described the use of a carbon burner, and of Swan, who in 1878 gave a description of his lamp, which contained a carbon filament, or carbon pencil, which differed from Edison's only in point of thickness, and further pointed out that Mr. Lane-Fox and Prof. Tyndall both stated that to have a successful burner high resistance was necessary; and to get high resistance it was essential to have the conductor as small as possible. He maintained that if all the world had the right to use carbon burners in a lamp of the description given by Edison, every kind of carbon burner must necessarily be included. If the Swan lamp was known to all the world, how could they prevent any person from making Swan's carbon burner of a finer material, or substituting any other he might think fit, there being no novelty in the mode of making the carbon burner? He next proceeded to point out that the whole question turned upon what was a filament, and said that he would adduce evidence to prove that Swan's lamp, which was described after the date of Edison's patent, contained a carbon conductor—in other words, that the burner was a carbon pencil, and was simply the application of a well-known principle.

The Court then adjourned for the day.

COMPANIES' MEETINGS.

Brazilian Submarine Telegraph Company (Limited).

The twenty-fifth ordinary general meeting of the shareholders of the Brazilian Submarine Telegraph Company (Limited) was held at the Cannon-street Hotel, London, E.C., on Wednesday, the 12th May, under the presidency of the Right Hon. Viscount Monck.

The SECRETARY (Mr. Richard Collett) read the notice convening the meeting and the minutes of the last ordinary and extraordinary meetings, which were confirmed. The report of the Directors was taken as read.

The CHAIRMAN stated that the report told them almost everything that he could tell them. They would observe that all their property was in good condition, their cables were working efficiently, and they had enjoyed in the past half year—and he was happy to say up to that moment — immunity from accident, which had diminished their expenditure compared with the previous half year by the sum of between £6,000 and £7,000. These were the favourable features—the bright side of the picture; but he was sorry to say that they would also have observed from the returns given of the income of the Company that they were not in the same flourishing state, in a pecuniary sense, as they had been in the habit of being. Their income

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had diminished in the half-year they were now considering; but there were causes in operation—which they might hope would cease—which accounted for that. There had been an unhappy monotony in almost every company of a commercial character, the chairmen having had to refer to the depressed state of trade for several years past. Very curiously their own Company was not affected up to about a year ago, and their income went on growing; but now they seemed to be sharing with other companies, and similar enterprises to their own, the effect of the depression, and their income had been reduced. There was another reason for the reduction in their own case—namely, the state of exchange between this country and Brazil. A good deal of their income was collected in Brazil, which, of course, they were obliged to transmit here, and if the exchange was against them they suffered. That state of things had, however, improved. An improvement in the value of the milrei had taken place, and was continuing, he was happy to say, and so far that cause would cease to affect their income to a certain extent. They were also suffering from a certain amount of competition on the part of the West Coast Company, which, of course, they could not avoid. They could only meet it in the best way they could; but they were now engaged in negotiations—which it would not be wise further to enter into—for consolidating and improving their position in Brazil, and which would, to a great extent, get rid of difficulties of that kind. He did not think there was anything in the accounts which called for any remark from him. He would be glad to answer any questions which might be asked. He concluded by proposing the adoption of the report and accounts.

Sir THOMAS FAIRBAIRN, Bart., seconded the motion.

Mr. W. GRIFFITH thought the Chairman had presented them with a somewhat gloomy picture of the past half year's working. He wished to know whether, since the beginning of the present half year, the falling off in the receipts had continued. If the dividend should fall below 6 per cent. per annum he trusted that everything possible would be done to reduce the expenses. The Chairman had stated that the exchange had improved, but he could not understand how they could be affected by this matter. He also asked for further information regarding the African Direct Company — the amount of debentures issued and the prospects of that company? He would also like to know more about the negotiations to which the Chairman had referred, and whether the Western and Brazilian Company were parties to the proceedings.

The CHAIRMAN, in reply, said it was obvious that if they had to turn milreis into pounds sterling in order to transmit the money home, they must lose by the conversion, if Brazilian money bore a less value than English money. That was how they were affected by the question of exchange. As to the African Direct Company, he thought that question was fully discussed at the meeting last January. Up to the present nothing had been done beyond proceeding with the construction of that line of telegraph, and they could say nothing more than they could last January as to the probable results in a pecuniary sense. Those who were best qualified to judge thought it might be profitable for the Company. The traffic from the West Coast of Africa would pass over their lines, and they would have whatever benefit was to be derived from that. The negotiations he had alluded to were in progress, and he believed they would result in very great advantage to the Company; but beyond that he hoped the meeting would not ask him to go. He did not think the shareholders had any reason to regret the confidence which they had reposed in his colleagues and himself for the last twelve or thirteen years. The general object of the negotiations was to consolidate and improve the position of the Company. Before any arrangement was finally concluded the opinion of the shareholders would be taken. As to Mr. Griffith's other question, he was sorry to say that the traffic did not show any recovery yet.

The resolution was adopted.

On the motion of Mr. LEWIS WELLS, seconded by Mr. JOHN ANDERSON, a vote of thanks was passed to the Chairman and Directors, and the proceedings then terminated.

Submarine Cables Trust.

The fifteenth ordinary annual meeting of the certificate holders in the Submarine Cables Trust was held at the offices of the Trust, Winchester House, No. 50, Old Broad-street, on Tuesday, the 11th inst., Mr. John Pender presiding.

The SECRETARY (Mr. Lewis Wells) read the notice convening the meeting, together with the minutes of the previous meeting. The report and statement of accounts were taken as read.

The CHAIRMAN: Gentlemen, the actual revenue of the Trust for the year ending April 15th, 1886, amounted to £18,838, as against £23,493 for 1885. This falling off of £4,655 is explained in the report as having been caused entirely by the diminished dividends paid by the Anglo-American Company, in consequence of the Commercial Cable Company having forced the Atlantic Companies to reduce the tariff from 2s. to 1s. 8d. per word. As it required £21,635 to cover our coupons and expenses, it is evident that but for the large balance brought into the accounts from the previous year and the accidental circumstance of our having five quarterly dividends from the Eastern Extension Company to deal with, we should not have been able to pay our coupons in full. Practically, we began our last financial year with a balance of £4,937, and we carry forward £2,140. Now, gentlemen, that is precisely the state in which we stand at the present moment. As to our future, a great deal depends upon how long the fight will continue in the Atlantic. I hope common sense will come to the rescue soon, and that we shall not be obliged to go on working at an unremunerative rate, but that some arrangement may be come to whereby the public and the shareholders will be equally and fairly served. We should be very glad to find as a Trust for telegraph shares that the tariff which is reduced to 6d. would fill the Atlantic cables. If it did fill the Atlantic cables, there could be no doubt that a very much lower rate than that which has been current of late years would be the permanent rate. But as far as our experience has as yet gone, we cannot say that the present rate is likely to be a permanent one. I hope that before we meet again this question will have been settled, and that we shall be working at something like fairly remunerative rates so as to enable us to continue to pay our coupons in full. With these remarks I beg to move, "That the report and accounts of the trustees now submitted to the meeting be approved and adopted."

Sir DANIEL GOOCH, Bart., seconded the resolution, which was carried unanimously.

On the motion of Mr. FORD, seconded by Dr. PRESTON, the auditors, Messrs. John G. Griffiths and John Gane, were reappointed, and a vote of thanks having been accorded to the chairman and trustees, the proceedings terminated.

Great Northern Telegraph Company of Copenhagen.

The annual general meeting of this Company was held at Copenhagen on the 21st April, F. Zahle, Esq., in the chair.

The CHAIRMAN of the COMPANY (C. F. Tietgen, Esq.) addressed the meeting with regard to the general business during the working year of 1885, and, referring to the state of the Company's cables, said that although the Directors that evening would have the pleasure to report satisfactorily about the results of the year, there was not much to say under this heading. The usual interruptions of the cables, which could not be avoided, had again occurred; but having in themselves at no time been of an alarming nature, the repairs had, thanks to the efficiency of the Company's two repairing steamers, the "H. C. Oersted" and the "Store Nordiske," stationed respectively in Europe and in the Far East, and thanks to the efforts of the Company's excellent staff, been most speedily effected. During such interruptions the traffic of the Company had in no way suffered, as the duplication system of the Company had provided the means for supplying a ready outlet for the traffic which had originally been intended for the line interrupted for the time being. The only drawback of these repairs had been, as must always periodically occur, that the stock of spare cable used for repairs had to be replenished, and the Company had therefore incurred an expense by ordering a new supply, the comparatively small cost of which had been included in the amount shown in the balance-sheet as deducted from the reserve fund. The Northern land line, passing through Siberia and connecting the Company's European cable net with their lines in the Far East, had in May, 1885, been interrupted for a fortnight, in consequence of inundations caused by the breaking up of the ice. These interruptions had in late years been very unusual, and the strenuous efforts which are being made to prevent such occurrences would guarantee against them in future. The traffic receipts had been highly satisfactory, and exceeded—theoretically, at least—the receipts in the prosperous year of 1884. Practically this excess, and more even, had, however, unfortunately been absorbed by the loss of exchange on remittances. As the shareholders would be aware, the Company collected their rates in the Far East in Mexican dollars, and whilst ten years ago about 4s. 3d. could be remitted for a dollar, the Company now barely received 3s. 4d. Considering that more than half a million dollars was annually remitted in this manner, a heavy loss would therefore naturally result, and the large amount figuring on the debit side of the profit and loss account was thus explained. The great event of the year had been the International Telegraph Conference, which had been assembled at Berlin from the 10th August to the 17th September. Without entering into the details of different measures which had been laid before the Conference, he would at once refer to the proposal of the German Administration with regard to the introduction of a uniform international telegraph tariff between any two countries within the limits of Europe—a project which had already been before the previous Conference held in London in 1879. It was brought up again on this occasion; but although it would be impossible not to admire the large views and noble sentiments upon which the conception of this idea was based, it would have been equally impossible to overlook the fact that, if carried out practically, it would have resulted in ruinous pecuniary losses, not only to a large portion of the Government Administrations concerned, but also, and much more grievously, to the private Companies in whose hands are now nearly all the international cables in Europe. Although the measure did not pass in its entirety, the tendency of the original proposition had been so strong that in the result serious tariff reductions were adopted, and notably as regarded the telegraph correspondence between the more distant countries in Europe. It would naturally follow that in such circumstances our Company, whose cables carry a very considerable part of the European and extra-European traffic, would have to be prepared to suffer a loss in consequence of the reductions passed at Berlin. To give examples: A message of twelve words (which our experience now showed us to be a fair average of messages transmitted over the Company's lines) from Great Britain to Russia now costs 9s., whereas after the 1st July it would only cost 6s. 6d. The same with regard to China, for which country the rate from this country now is 8s. 4d. per word; whilst after the 1st July next it will only be 7s. 1d., and as the greatest proportion of these rates accrued to the Company we would consequently have to bear the greatest part of the proportion of the reductions. It should, however, gratefully be mentioned that the powerful Administration from whom the proposals for these reductions emanated, as well as other administrations who by their votes contributed to their adoption, had shown the Company every consideration in giving their consent to certain exceptions from the normal rules in favour of the cables. Special and well merited thanks were also

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due to the managing director, Captain E. Suenson, who had represented the Company at the Conference, and had carried on the negotiations with the greatest ability and care. These reductions would, however, no doubt have the effect of gradually increasing the traffic, and thus, to a certain extent, compensate for the losses which the Company would suffer. But then, again, such an increase of traffic would mean eventual increase of staff and of telegraph lines, and the Company would therefore have to be prepared sooner or later to resort to the reserve fund. For this reason the Directors had thought it right to propose once more to increase that fund in the same exceptional manner as in former years. In reference to the duplication of the line between Russia and Sweden, the Chairman said that in accordance with Conventions concluded with Russia and Sweden, the Company had already now obtained, free of any extra expense, a reserve line between St. Petersburg and Nystad in Finland, and another in Sweden between Grislehamn and Gothenburg. These two lines would be connected by the cable which had been laid by the Company between Sweden and Finland in 1883, and thus constitute a complete and direct line from St. Petersburg to Gothenburg, which would be of great advantage in the transmission of the traffic between Russia on the one side and Great Britain and France on the other side. At the same time, he would mention that the Company was now going to introduce instruments with certain improvements, which, after a fair trial, had shown that by their employment greater speed of transmission could be ensured within the carrying capacity of the cables. The position of the Company would thus be that they would be enabled to meet all requirements in case a considerable increase of the traffic resulted. But, unfortunately, the effect of the continued general stagnation of trade, industries, and navigation, which as regards the Company's revenue is no longer counterbalanced by the effect of political and military movements in the Far East, had already been felt in the amounts of the receipts as shown by the monthly traffic returns published since the beginning of this year. What with this falling off in earnings, and what with that which after the 1st July next would follow from the reduction of the rates, it could be foreseen that the Company's future income, and particularly that of the present year, would be considerably lower than that of previous years. Thanks to the further addition to the reserve fund, and to several other measures taken during previous good years, it could, however, be hoped that the exceptional circumstances referred to would not tend to diminish the dividend hitherto paid to the shareholders in any sensible degree. The feverish activity which the political events had called forth some years ago with regard to the development of the telegraph net in the interior of China had somewhat abated after the conclusion of the peace between France and China. The fact, however, remained that the telegraph had become a positive necessity for the Chinese, and no fears need therefore be entertained that further developments would be arrested. During the year several lines had been established, of which one of the most important was that which connected Seoul, the capital of Corea, with the Chinese telegraph system. This line, which had been constructed by the Company's engineers, of whom several had entered permanently into the Chinese service, would shortly be extended from Seoul to Fusan, the Japanese Colony on the South Coast of Corea, the landing place of the cable connecting Corea with Japan proper, which the Company had laid in 1883. The Company's instrument workshop at Copenhagen had been well employed, and had latterly received important orders for instruments. A variety of telegraph instruments, manufactured by the Company, had successfully been exhibited at an electrical exhibition at Gothenburg during the month of June. 1885. The balance-sheet, which had been in the hands of the shareholders for some time past, had shown that after all the general charges, as well as the ordinary charges for interest and amortisation of debentures, and the payment of the usual 5 per cent. interim dividend during the past year, had been provided for, there remained an amount of £133,699. 13s. 6d., which the directors submitted to the meeting to deal with as follows :—£45,833 6s. 8d. to be divided amongst the shareholders as an extra dividend of 3 per cent. (making the dividend for the year, including the interims already paid, 8 per cent.) ; £2,777. 15s. 7d. to be allotted to the pension fund for the staff ; £55,555. 11s. 1d. to be added to the reserve and renewal fund ; and £29,533. 0s. 2d. to be carried forward to next year's account. Without discussion the propositions of the Directors were unanimously adopted, the accounts were passed, and the usual discharge was given to the Directors.

L. P. Holmblad, Esq., the retiring director, was unanimously re-elected.

A. Berner, Esq., and Aug. Garde, Esq., were likewise unanimously re-elected as shareholders' auditors.

The proceedings then terminated.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. MAY 12.		BUSINESS DONE WEEK ENDING MAY 12. Highest.	Lowest.
Anglo-American	30½,	31½	31½	30¾
Do. Preferred	51½,	52½	52¾	52
Do. Deferred	9¾,	10¼	10	9 15-16
Brazilian Submarine	10⅜,	11	11	10⅝
Cuba	10½,	10¾	10⅝	—
Do. Preference	18,	19	—	—
Direct Spanish	1½,	2	—	—
Do. Preference	9,	10	9	—
Direct United States Cable	8⅞,	9	9½	8⅞
Eastern Telegraph	10½,	10¾	10⅝	10½
Do. 6 per Cent. Preference	14½,	14⅝	14 5-16	14¼
Do. 5 per Cent. Debentures, 1899	105,	108	—	—
Eastern Extension	11⅝,	11¾	12	11⅝
German Union	9¼,	9⅝	9 11-16	9½
Globe Telegraph and Trust	6½,	6¾	6¾	6 9-16
Do. Preference	13½,	13½	13⅝	13½
Great Northern	13½,	13¾	13⅞	13⅝
Indo-European	34½,	35½	34¾	34½
Reuter's	6,	6½	—	—
Submarine	200,	210	207	—
West India and Panama	¾,	1	—	—
Do. 1st Preference	8¾,	9¼	9¼	8¾
Western Brazilian	7⅛,	7⅜	7 1-16	—
Western Union 7 per Cent. 1st Mortgage	118,	122	—	—
Do. 6 per Cent. Sterling Bonds	103,	107	103¾	—

TELEPHONES.

Consolid. Telephone and Maintenance	13-16	15-16	⅞	—
Oriental	3-16	5-16	—	—
United Telephone	12⅞,	13⅛	13	12⅞

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	2¾,	3	—	—
Do. (fully paid)	4¾,	5	4½	—
Swan	1⅛,	1⅜	1⅜	1 3-16
Maxim-Weston	3-16	5-16	¼	—

MISCELLANEOUS.

Telegraph Construction	36½	37½	37½	37
India Rubber, Gutta Percha, and Telegraph Works	22	23	22¾	22

TRAFFIC RECEIPTS FOR APRIL, 1886

COMPANIES.	April, 1886.	April, 1885.	Increase.	Decrease.
Cuba Submarine	3,300	3,886	—	583
Direct Spanish Telegraph	1,597	1,510	87	—
Eastern Extension	34,292	41,233	—	6,941
Eastern Telegraph	47,611	63,085	—	15,474
Great Northern	19,800	—	—	—
West Coast of America	3,225	—	—	—

CITY AND GUILDS OF LONDON INSTITUTE.

CENTRAL INSTITUTION, EXHIBITION ROAD, S.W.

PROF. AYRTON, F.R.S., will continue his Course of Lectures on SOME OF THE INDUSTRIAL APPLICATIONS OF ELECTRICITY, on FRIDAY, MAY 14th, at 5 p.m. Subjects : May 14th and 21st, THE ELECTRIC TRANSMISSION OF POWER ; May 28th, ELECTRIC LOCOMOTION.

Persons who have not already joined the Course can do so on payment of a fee of Five Shillings.

PHILIP MAGNUS, Director and Secretary.

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NOTES.

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 14th inst. amounted to £2,800.

PHILADELPHIA.—There are now 344 electric lights in the streets and public places of Philadelphia. The city pays 54 cents per lamp per night.

TELEPHONY IN SCOTLAND.—The *Aberdeen Journal* says:—"The National Telephone Exchange Company have arranged to connect Johnstone with Paisley and Glasgow."

PLYMOUTH, PA.—The electric light has met with great favour in this town. There are at the present time 32 arc lamps in use in the streets, and this number will shortly be increased.

THE WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended 15th inst. are £2,774, as compared with £3,780 in the corresponding period of 1885.

ROYAL SOCIETY.—A paper by Dr. G. Gore, F.R.S., on "The Relations of Transfer-Resistance to the Molecular Weight and Chemical Composition of Electrolytes," was read before the Royal Society at the meeting on Thursday, the 20th inst.

SMALL DYNAMOS AND MOTORS.—Prof. Anthony and Lieut. Murdock have carried out a series of experiments at the Cornell University upon a number of small dynamos and motors. The full report is given in our American namesake.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 14th inst. were £2,230, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

HENLEY'S TELEGRAPH WORKS.—We are informed that the fire which occurred on the premises of this company on the 16th inst. will in no degree interfere with the course of business, the building destroyed being merely a storehouse situated at some distance from the works.

ELECTRIC LIGHTING BILLS.—The Select Committee of the House of Lords on Electric Lighting Bills continues its sittings, under the presidency of Lord Camperdown. Various witnesses have been examined, among others yesterday Mr. George Morrison, town clerk of Leeds.

TEMPORARY LIGHTING.—The electric light was used to great advantage in the Greek plays which took place at Princes' Hall, Piccadilly, at the end of last week. The temporary lighting was admirably carried out by Mr. Montagu Scott. The light was obtained by means of E.P.S. accumulators.

CITY COMPANIES' HALLS.—On Wednesday, the 12th inst., the magnificent halls of the Drapers' Company were lighted for the first time by electricity, the work having been carried out by the Electrical Power Storage Company. There were 212 incandescent lamps used of 20 candle-power.

THE SOCIETY OF TELEGRAPH-ENGINEERS.—The next meeting of this society will be held at the Institution of Civil Engineers on Thursday, 27th inst., when the following papers will be read:—I. "The Telephone as a Receiving Instrument in Military Telegraphy," by Capt. P. Cardew, R.E., member; II. "On a Problem relating to the Economical Electrolytic Deposition of Copper," by Capt. H. R. Sankey, R.E.

AMERICAN INSTITUTE.—The second annual meeting of this institute was to commence on 18th inst., when the officers would be selected. Among the papers to be read are "Recent Progress in Telephony," "Incandescent Lighting from Central Stations," "Secondary Batteries for Light and Power," "Patent Office Practice," "Subterranean Electric Systems," and the "Static Difficulties in Multiplex Telegraphy."

THE CONSOLIDATED.—Our readers will have noticed that another of the electric light companies born in the time when gigantic hopes were rampant has come to grief, and that Messrs. Wheatley Kirk, Price, and Goulty have sold their plant under the hammer during this week. No doubt many have availed themselves of the excellent opportunity to obtain good machinery and appliances under favourable conditions.

PARIS AND GAS.—The report of the Parisian Company for lighting and warming by gas says that the consumption of gas in Paris and the outskirts has diminished. They do not attribute this fact solely to electric lighting, though it no doubt has largely contributed to this diminution. They propose making a special offer of gas for gas engines for working the electric light instead of the cumbersome steam engines. They thus hope to reinstate their trade.

THE "ELECTRA."—According to *The Times* correspondent, the Eastern Telegraph Company's steamship "Electra" has proved of great service in the political crisis in Greece. The "Electra" was chartered by the Government, and the Duke of Edinburgh granted her a pass and all facilities to bring the Grecian deputies from the various islands to the mainland. She brought deputies from Stelytha, Oreos, Volo, Scopelos, Skiathos, and Kumi, and afterwards returned to Syra.

ELECTRIC CONDUCTORS.—A commission has been appointed in France to consider the regulations that should hold good for the installation of electrical conductors. By decree of the 24th April the following gentlemen formed the commission:—MM. Marcel Deprez, Lemonnier, D'Arsonval, and Violet. The commission will prepare rules and fix the technical conditions in order to assure the security of the public in the installation of conductors affecting the transmission of electrical energy.

STATE OF SOUTH KENSINGTON WATER COLOUR DRAWINGS.—An alarming report is current in artistic circles that the water colour drawings at the South Kensington Museum are showing signs of deterioration. Mr. Agnew has taken the matter in hand, and will on Monday ask the Vice-President of the Council to appoint a committee to inquire into it. It is further desired that the committee should report on the best means of exhibiting such works, the best means of conserving them, and the effects (if any) of electric light upon water colour pigments.

INDIAN TELEGRAPHS.—The report of the Telegraph Department for 1884-5 shows that the financial outcome of the year's work gives a return of about 3·3 per cent. interest on capital expenditure. During the year over 6,000 posts and seven miles of cable were added to the system. The Burma-Siam line was completed, and the new cable connection made between India and Ceylon. Great extensions are being made in Upper Burma, and when these are finished the Indian telegraph system will afford means of communication between Bhamo and Quetta, as it does now between Bangkok and Kashmir.

ELECTRIC CAR.—Mr. John C. Henry, of the Henry Electric Railway Company, Kansas City, Mis, writing to the *Scientific American*, says:—"On January 29th I hitched our electric car Pacinotti to a Kansas City, Fort Scott, and Gulf coal car, weighing 17,500lb., and took it up a 2½ per cent. grade. Yesterday I coupled the same motor car to a Chicago, Burlington, and Quincy box car 19,178, weight 24,500lb., and started it without jerking on a 3 per cent. grade. I claim the distinction of being the first to haul regular standard gauge freight cars by electricity, and would be pleased to have you record it."

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NEW BOOKS.—Messrs. Whittaker and Co. and Messrs. Bell announce in their new "Series of Handbooks for Practical Engineers" Dr. Jul. Maier's book on "Arc and Glow Lamps." It will be a complete handbook on the subject, especially relating to its practical applications, giving the latest results and improvements. The next volume of the same series will be Mr. Gisbert Kapp's "Electric Transmission of Energy," which is promised early next week. Mr. Wm. Anderson has revised and added some new matter to his "Lectures on the Conversion of Heat into Work," which excited much attention when delivered last year at the Society of Arts. They will be published in book form by Messrs. Whittaker and Co.

THE NATIONAL TELEPHONE COMPANY.—Nearly twelve months have passed since the Whitehaven and Workington Exchanges were opened for business. Beginning with 19 subscribers on the list, the number has now increased to 56, an increase of 37. The total number of messages which have passed through the exchanges during this time reach the grand total of 43,757. As the average time taken to transmit each message was about three minutes, and as 300 words can easily be exchanged in that time, it is calculated that no fewer than 13,127,100 have been exchanged between subscribers since the opening of the exchanges. The value of the telephone as a means of communication is now fully understood and fully appreciated by all business men.

DISGRACEFUL CONDUCT.—Mr. P. G. Behn, described as an engineer and electrician, of 72, Queen Victoria-street, City, was charged at Croydon on Wednesday on two summonses with travelling on the London, Brighton, and South Coast Railway without having previously paid his fare, and with intent to avoid payment thereof. Sergeant Potter, of the railway company's police, stated that the defendant was convicted of a similar offence at the Lambeth Police Court on March 18 last, when Mr. Chance fined him 40s. and 23s. costs, that being the full penalty. The Mayor observed that the accused had shown nothing but falsification all through. He had been guilty of a most mean fraud, which was aggravated in every particular. He would have to pay a fine of 40s. and 9s. costs for each offence, in all £4. 18s.

ITALIAN TELEGRAPH STATISTICS IN 1885.—A summary of the working of the Government wires in 1885 has been issued from the General Telegraph Department. The private telegrams transmitted in the interior amounted to 5,896,306, showing an increase of 244,028 compared with 1884, and the messages for abroad 581,657, or an increase of 13,386 on 1884. The Government and service telegrams were 664,358. The number of telegrams received from abroad was 687,423, showing an increase of 22,922. The gross receipts are set down at 13,694,194 lire, say £547,770, and the expenditure at 10,952,048 lire, say £438,080. The total length of the lines on 31st December last was 30,021 kilometres, an increase of 833 kilos. The length of telegraphic wire was 106,755 kilometres.

A MIRACULOUS ESCAPE FROM LIGHTNING.—A Madras telegram to the *Times of India*, dated the 19th April, says:—"Last Friday, Bishop Caldwell and Mrs. Caldwell had a miraculous escape from a stroke of lightning. The Bishop and Mrs. Caldwell were sitting at tiffin in their house at the Pulney Hills, when lightning coming through the iron roof passed through four rooms in succession, causing considerable damage, making a furrow along the ground, and burying itself in a hole which it made. Two servants were knocked down, and one was rendered temporarily insensible. Five persons received shocks; but none were killed. The Bishop and Mrs. Caldwell were surprised to see a ball of fire come between them and seem to explode on the table. Mrs. Caldwell received a slight shock only."

EDINBURGH EXHIBITION.—The Town Council of Edinburgh have lately been considering in committee the desirableness of improving the lighting of the approaches to the Exhibition, and last night a sub-committee visited Brougham-street with the view to ascertaining if some addition to the illuminating power of the gas was necessary. At present, only each alternate lamp is lit in most of the thoroughfares of the city, but the opinion of the committee appeared to be that, on account of the greatly increased traffic in and around Brougham-street, not only should every lamp be utilised, but if possible an electric light should be placed in such a position in front of the Exhibition as will illuminate the surrounding space for a considerable distance. A recommendation to this effect will probably be made to the council at their next meeting.

SOUTH AFRICA.—According to the *Diamond Fields Advertiser*, the electric light played an important part in the criminal proceedings relating to the dynamite conspiracy. According to one of the witnesses, he was able to identify the accused because the latter got directly between him and an electric light, which was at a distance of some 360 yards. The witness said:—"Anyone standing in the window where I stood would catch an object coming between them and the electric light very distinctly," so that not only in America, but in more thinly populated districts, the question of more light should have some effect upon decrease of crime. We all remember Mr. Preece's remark to the effect that an increase in electric lighting would lead to a decrease of policemen, and the more we consider the subject the more this seems to be the case.

GLOW LAMPS FILLED WITH HYDROGEN.—The *Elektrotech. Zeitschrift* of April, 1886, says that lately the Bros. Siemens have been manufacturing glow lamps, whose glasses are filled with hydrogen. It had been remarked before that glow lamps in which the inner glass wall had been rendered brown could be cleaned by filling them with hydrogen and then exposing both the carbon filament and glass to a high temperature. These lamps are said never to become brown at all, and to last longer. They can be used with higher electromotive forces, and consequently under conditions considerably more favourable to economy, without diminishing their wear. It is thought that many evils which are found in the vacuous glow lamps now in use will disappear when the carbon filament is in an atmosphere of a gas exerting considerable pressure, but not acting chemically upon it.

FRENCH PHYSICAL SOCIETY.—At the Exhibition of the French Physical Society, which was opened on the 27th and 28th of April, the telephonic apparatus of M. Mercadier was especially interesting. In one telephone the membrane was strewn with iron filings, which placed themselves along the force lines. The working of this instrument proves that in a telephone it is immaterial what is the form, the rigidity, and the continuity of the magnetic system whose movements produce and reproduce the sounds. A telephone with an aluminium membrane proves that telephonic effects may be obtained by electro-magnetic induction of currents, as well as by magnetism in the membrane, though, of course, iron gives results of greatest intensity. Another telephone with a copper membrane was strewn with iron filings. Here there is the superposition of the magnetic effects in the iron, and the inductive ones in both the copper and iron.

FRENCH TELEGRAPHS.—We are now able to give a little further information upon the telegraphic reductions just made

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in France. M. Granet, the Minister of Posts and Telegraphs, has decided on a reduction of 50 per cent. on the existing tariff for telegraphic news addressed to the newspapers. This reduction will come into force on 1st June. Special letters, for the purpose of identification, will be issued by the Minister of Posts and Telegraphs to the correspondents of those papers which desire to benefit by the reduced rates. There will be no limit as to the number of words sent under the new tariff. M. Granet intends to do away with the obligation at present imposed upon senders of telegrams of giving their signature and address at the foot of the telegram. But as this formality was imposed by the law of the 8th May, 1867, it can only be repealed by the Chamber, and a measure to this effect will be laid before the French Parliament.

Electric Light in France.—The value of the electric light is gradually making itself felt, and according to our contemporary *L'Electricien* the small town of Bourganeuf, of four thousand inhabitants, has adopted the electric light. The initiator of the scheme was M. Ernest Lamy, who adopted the simple plan of endeavouring to introduce the light into the small towns which are not yet lighted by gas, and which have water power used during the day in various industries and during the night as the motor power for driving the dynamos. About 300 lamps will be installed, of which little more than 100 will be generally in actual use. The motor power is obtained from an old water wheel, driving a Thury dynamo with 6 poles, compound wound, making 450 revolutions per minute, giving normally 111 volts at the terminals of 180 amperes, but capable of producing 225 amperes. The distribution is by means of aerial insulated wires. The lamps are by Messrs. Woodhouse and Rawson.

Plating Without Electricity.—A curious phenomenon has been observed by M. Blondlot, and communicated to the French Academy of Sciences. A disc of platinum and a disc of copper, 0·03 metre in diameter, were fixed vertically in front of each other by help of two platinum stands. The discs were three or four millimetres apart, and both were placed inside a bell jar of porcelain, open below. The apparatus was then heated red hot for three hours by means of a gas furnace; and although there was no electric current, it was found that the face of the platinum disc was blackened with a deposit containing copper and platinum. In short, the copper had crossed from the copper plate to the platinum one. M. Blondlot, by repeating the experiment in different gas, found that the nitrogen of the air was the agent in this transport of matter. The nitrogen combines with the copper, and lodges on the platinum, either incorporating itself with the latter or decomposing in contact with it under the influence of its high temperature.

A Chemical Process for Making Carbon Filaments for Incandescent Lamps.—This process is described by Mr. A. Smith in *Dingler's Polytechnisches Journal*. Hydrogen chloride is passed through furfuraldehyde, or fucusaldehyde, and a black liquid is obtained that is placed between two glass plates. From this liquid a thin layer of carbon separates after eight or ten hours, and the thickness of the layer is regulated by inserting wires between the plates. This layer is removed, cut into strips, and twisted, and heated to 100 degrees C. Afterward, these filaments are heated in closed crucibles, through which a current of marsh gas is passed. Their electric resistance can be changed by the addition of 2½ per cent. of lamp black to the furfuraldehyde. For the preparation of carbon rods for arc lamps finely powdered carbon is mixed with from 60 to 70 per cent. of furfuraldehyde, and the mixture subjected to powerful pressure in suitable moulds. The rods thus formed are exposed to the action of gaseous hydrogen chloride, after which they are highly heated in closed crucibles covered with powdered carbon.

The B.A. Meeting at Birmingham.—The Gülcher Electric Light Company have secured the contract for lighting Bingley Hall during the Association Meeting to be held in September. The installation is to be carried out under Mr. Henry Lea, the consulting engineer, and will be of a very complete nature. The interior of the hall is to be lighted with 28 3,000 candle-power Gülcher arc lamps. Old Birmingham, which it is anticipated will form a very attractive part of the Exhibition, will be lighted with 160 incandescent lamps, suspended either by flexible pendants or upon suitable fittings. The current for driving the 28 lamps and 160 incandescent lamps will be generated by four compound wound Gülcher dynamo machines of their latest and most improved type. Three machines will be in actual work, the other being used as a spare one in case of accident. The motive power for driving the installation is to be provided by Messrs. Tangyes', Birmingham. The engine will be of the double cylinder horizontal type. The London and North Western Railway Company supply the boiler power from one of their locomotive boilers, which they have lent for the occasion.

Electrical Quacks.—We are glad to see that in France some attempt is being made to punish the men who attempt to make money out of the ignorance of the general community. We are sorry there is no institution in England to take up the prosecution of many of the quacks who are continually advertising electric and magnetic appliances which are utterly worthless to effect the purpose they are said to effect, and we should be glad to chronicle similar prosecutions and similar results to that of Lyons. A man named Tournus was summoned before the Lyons Correctional Tribunal on the charge of unlawful practice of medicine. He professed to be able to cure baldness by means of a certain magnetic water, to which he imparted the mysterious fluid in presence of his patients. The defendant produced a testimonial from a person who declared the results of the lotion were magical, and enclosed as a mark of gratitude a cheque for £20. He had also sold extensively what he called electro-vegetable pomade. Tournus, who in answer to a question of the judge said he had tried his magnetic restorer upon himself, is notwithstanding perfectly bald. The tribunal sentenced him to pay a fine of 15fr. and the costs.

Tasmania.—Mr. W. L. Dobson, Chief Justice of Tasmania, in the course of a paper, which he read recently before the Royal Colonial Institute, on Tasmania, said there is a network of telegraphic wires all over the inhabited portions of the colony, whilst a duplicated submarine cable has been laid across Bass's Straits from Tasmania to Victoria; and thus the colony is placed in connection with the telegraph system of the rest of the world. What are we doing here to-night will probably be telegraphed to Australia, and will, with the other news of the day, appear at breakfast-time to-morrow morning in the daily press of Tasmania. The new system of telegraph communication now organising in Canada may prove to be beneficial to Australia and the East. It appears the Canadian Pacific Railway Company is organising a system of trans-continental telegraphic communication stretching from the Atlantic to the Pacific, and having connections with all the principal American lines and Atlantic cables. When this new telegraphic system is completed it will be one of, if not the, most thorough and complete systems of telegraphy in the world. At present the company are working three

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wires between Montreal and Winnipeg, and a fourth wire is now being laid. It is expected that the entire system will be opened for commercial purposes early this summer.

ELECTRIC LIGHTING FOR TORPEDO BOATS.—The Admiralty has just placed with Messrs. Willans and Robinson, of Thames Ditton, an order for engines and dynamos for thirteen sea-going torpedoboats. The engines are of the well-known Willans three-tandem type, and they are coupled direct to dynamos by Messrs. R. E. Crompton and Co., giving a current of 50 amperes and 80 volts. The revolutions are 650 per minute. Under a recent patent of Mr. Willans the crank chamber of the engine is made in one casting, with a frame which supports the magnets, and which also carries the bearing at the outside end of the armature spindle. The ordinary frame of the dynamo is thus dispensed with, and there is a still further saving in weight through substituting the single casting described for the independent crank chamber and bed plate usually fitted. The same plan has recently been carried out in some large engines of the central valve type, made by the same makers for H.M.S. "Rodney" with complete success. In that case the dynamos are by Messrs. Siemens. During the last twelve months Messrs. Willans and Robinson have received orders for no less than 37 engines for lighting English torpedo boats, besides some for foreign governments. In the same period they have had orders for 24 larger engines, mostly indicating about 35 indicated horse-power (with comparatively low pressures) for incandescent lighting in large vessels of the English navy, and for about as many engines of medium size for search lights.

ELECTROMOTIVE FORCE OF ZINC-COPPER AND LEAD-PLATINUM COUPLES.—From a large number of determinations of the electromotive force of the currents yielded by zinc-copper and lead-platinum couples in various simple saline solutions, B. C. Damien—*Ann. Chim. Phys.*—finds that the electromotive force, as a rule, decreases with the time the couple is immersed. In the case, however, of the zinc-copper couple in solutions of the chlorides, the electromotive force at first slowly increases. The electromotive force of the current yielded by a zinc-copper couple in a solution of magnesium sulphate is very constant, scarcely varying 0·017 volt during twelve months, and is not appreciably affected by changes either of the strength of the solution or of temperature. By introducing an exterior resistance of 20,000 ohms, the current becomes practically invariable, even when the couple is kept in circuit. The author proposes to employ this couple for the generation of currents of standard strength. The zinc-copper couple yields currents whose electromotive force is almost identical for members of any class of salts containing a given acid, but varies greatly with a change of acid. Amalgamation of the zinc slightly increases the electromotive force at first, but it decreases more rapidly than is the case when unamalgamated zinc is employed. The current obtained from a platinum and amalgamated zinc couple in dilute sulphuric acid has its maximum electromotive force when its solution contains 30 per cent. of acid.

GAS COMPANIES IN SPAIN.—We recently referred to the decision of gas consumers of Madrid to dispense with that mode of lighting, and to replace it by electric light; but Madrid does not appear to be the only town in Spain in which dissatisfaction with the gas companies is beginning to manifest itself in active opposition. According to advices from Cadiz the dispute over the lighting of the town has recently become so acute as to threaten a breach of the peace. Hitherto the the town has been supplied with gas by a company established in Paris (E. Lebon and Co.). On the termination of the contract a local company was formed (the Sociedad Co-operative Gaditana), and, with the approval of the present Ayuntamiento, immediately commenced operations by erecting works and laying pipes, &c., though hampered by threats of litigation by the French company, which appears to have been promised a renewal of the concession by the former Ayuntamiento. The matter has been brought to a crisis by a summary order from the Government for the suspension of the operations of the new company, much to the disgust, it is said, of the general public. Meetings have been held, at which it was decided to discontinue the use of gas, and return the meters to the Lebon company; to close the business establishments in the evening, pending some other arrangement; to organise a general support to the local company; to petition the Queen and the Government against the prohibitive order referred to; and in the meanwhile to use petroleum or some other light both in private houses and in business establishments.

DENVER.—The City of Denver, says the *Electrical World*, stands almost alone in this country in the matter of street lighting. Both arc and incandescent lamps are used in a combined system under one management. Another peculiarity consists in the fact that the Brush Company is running Edison lights. For arc lighting the Brush system is used. There are six towers, on each of which are six 3,000 candle-power arcs, and on another tower are four 3,000 candle-power lights. Besides these are seven masts, each of which carries a 3,000 candle-power light. This alone would give a good light, but in addition each of the 500 lamp posts that once held a dim, flickering little jet of gas is adorned with a 20 candle-power Edison lamp. The result is eminently brilliant and pleasing. The cost of the service is anything but large. The bid of the gas company was $35 a year per street lamp, whereas the incandescent lamps are furnished at $28. The arc lights cost the city $150 for each mast; $960 for the tower with four lights; and $1,296 for a six-light tower. Supplementary to the city lighting, the local company has 300 private lights in use, at $13 a month for 10 o'clock lights, $15 for 12 o'clock, and $20 for all night. The station is run by three engines—one 250 horse-power made by W. Wright, of Newburgh, New York; a Corliss of 166 horse-power, made by Fraser and Chalmers, of Chicago; and a 50 horse-power from Hendey and Meyer, of Denver. The capital of the company is $200,000. Mr. W. B. Rundle, a well-known electrician, is the superintendent, and Mr. R. H. Sterling is the electrician. The company is evidently doing a good business, and there is a project of forming two companies, with two plants, one to attend to the arc lighting and the other to handle the incandescent lighting.

THE AQUARIUM.—The Royal Aquarium, Westminster, has now been lighted for four months by the Gülcher Company. The installation consists of 23 Gülcher arc lamps distributed as follows:—Seven 3,000 candle-power arc lamps of the type used for indoor work, and suspended by the company's improved raising and lowering apparatus are used, for the interior lighting of the main building; six 2,000 candle-power arc lamps of a similar type are used for lighting the new dining hall; three 2,000 candle-power arc lamps light Messrs. Beckwith's diving and swimming departments; and seven 2,000 candle-power arc lamps, fitted with weather protectors and iron reflectors, are used for the outside lighting, three being placed at the front of the building and four along the side. Messrs. Bertram and Roberts's dining rooms are lighted by seventeen 20 candle-power incandescent lamps, eight being placed over the dining tables, three in the large private dining room, and two in the small room, the balance being used for lighting the manager's office, &c. The

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current for working the installation is obtained from three No. 4 Gülcher dynamo machines, placed in an engine house by the side of the hall, to which persons desirous of obtaining information of the installation can have access. The current from the machine is led to switches, so that any part of the installation can be lighted as desired. Suitable measuring instruments are also connected by means of switches to the machines, so that at any moment the attendant in charge can read either the amount of current flowing through any circuit or the E.M.F. at the terminals of either of the three dynamos. The motive power for driving the installation is obtained from one of Messrs. Roby's 16 horse-power engines, which has given great satisfaction, and runs with great regularity of speed.

Cost of the Electric Light.—For the last two or three years, week in and week out, scores of articles have been written discussing the cost of the electric light. In ninety-nine per cent. of these cases the basis for the calculations has always been an assumed quantity. It comes to be a different thing, however, when tenders are asked for supplying the light wherever these tenders may be sought for. We are then able to obtain some definite idea as to the cost of such light. Below we give the tenders for lighting Galesburg, Illinois, the city having asked the cost of 65, 85, and 100 light plants respectively :—

Brooklyn Electric Light Company—	
65 single arc lamp plant	$14,530.00
65 double carbon lamp plant	15,180.00
85 single arc lamp plant	15,080.00
85 double carbon lamp plant	16,080.00
100 single arc lamp plant	16,470.00
100 double carbon lamp plant	17,470.00
Thomson-Houston Electric Light Company—	
65 single arc lamp plant	$15,463.75
65 double service lamp plant	16,000.00
85 single arc lamp plant	16,899.00
85 double service lamp plant	17,600.00
100 single arc lamp plant	19,046.00
100 double service lamp plant	19,871.00
Brush Electric Light Company—	
65 single arc lamp plant	$11,099.75
65 double lamp plant	11,489.75
85 single arc lamp plant	14,514.60
85 double arc lamp plant	15,024.60
100 single arc lamp plant	17,076.00
100 double arc lamp plant	17,676.00
Fort Wayne Jenney Electric Light Company—	
65 light plant	$13,445.00
85 light plant	15,725.00
100 light plant	17,485.00
Sperry Electric Light, Motor, and Car Brake Company—	
60 arc light system	$7,000.00
85 arc light system	8,000.00

All the tenders were referred to the Street Lighting Committee.

Contact Action.—The tendency of all scientific investigation at the present time is to show the close connection of electrical with molecular phenomena, and anything throwing light upon the latter will probably ultimately assist in throwing light upon the former. Mr. D. Mendeléeff, according to the *Journal* of the Chemical Society, says : "It is a generally received opinion that not only the molecules as a whole, but each of the constituent atoms, are in motion, the movement of the latter being conditioned by the limits of the molecule. If the conception be reasonable, then in every state of aggregation there are presumably motions of two kinds, the one internal, the other superficial. The contact of two molecules, as also conditions of temperature, pressure, and electric potential, influence each kind of motion; thus the phenomenon of catalytic or contact action gradually passes into that of dissociation or of decomposition. Herein the decomposition of hydrogen peroxide is analagous to that of many detonating solids, in which a disturbance of atom-equilibrium at the superficies of the molecule causes its complete disruption. Now supposing two substances, A and B, are in superficial contact with one another, under such conditions that not only the superficial movement of the constituent parts, but also of the molecule as a whole is disturbed, then three distinct cases are possible :—Firstly : The atoms change their kind of motion without returning to their former state of equilibrium ; no chemical change ensues, but merely a physical phenomenon, such as alteration of electric potential, condensation of gases, whether by cold surface or by porous substances. Secondly : The internal movement of the molecules is altered, so that molecules of a different kind are formed by combination, replacement, or decomposition. These changes are accompanied by an alteration of the energy of the system, but although the total heat effect observed is the algebraical sum of the energy changes, conditioned by the several changes of motion, yet thus far it is not possible to assign to each particular change its peculiar heat effect. As an example of chemical changes induced by the mere superficial contact of the molecule as a whole, the author quotes the well-known experiments of Spring on the combination of metals with sulphur by mere pressure. Thirdly : The motion of the atoms within the molecule taken by itself can be of such a kind as to produce a chemical change of formation of a molecule of a different kind, such as the so-called isomeric transformation. Or, again, the superficial contact of B with A, a mixture of heterogeneous molecules may cause either a decomposition or a combination between them, as exemplified in the experiments of the Hautefeuille and Lemoine, which demonstrate that the presence of porous substances can induce the combination of hydrogen with iodine, and conversely the decomposition of hydriodic acid, both reactions attaining a limit. Of a similar nature is the combination of hydrogen with oxygen, induced by contact with finely divided platinum, and also the recent experiments of Konovaloff on the decomposition of haloïd derivatives of pentane by contact with materials in a state of fine division. These phenomena are generally classified under the title of catalytic or contact actions. Such can only be explained on the hypothesis that a stable substance B is in such a condition that moderate perturbation of the constituent atoms at its superficies produces no disturbance in the atom equilibrium of the molecule ; whilst in the case of a changeable substance A, the equilibrium of atoms within the molecule is of such a kind that a comparatively unimportant change of motion at the superficies can cause the atoms to assume a different form—that is to say, can cause the production of a different kind of matter. If this be a correct representation of these contact phenomena, then the induced reaction should either be accompanied by a slight heat change, or if accompanied by a considerable heat change, then the reaction should be capable of proceeding by itself in the direction of the heat evolution. An example of the former case is the reaction between hydrogen and iodine; of the latter is the system of hydrogen with oxygen in contact with platinum, which causes a lowering of the reaction-temperature. In conclusion, it is remarked that it is desirable to find a method of research, not only to explain the connection of contact action with other kinds of chemical change, but also even of the mechanism of the chemical change itself."

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PRACTICAL ELECTRICITY FOR AMATEURS.—II.*

Electric Bells and Indicators.

Bells are occasionally required to ring continuously when once started. One arrangement is shown by Fig. 6. The action is as follows: upon the push being pressed, the current enters at C, passes through the coils and contact to L. This causes the armature to be attracted, which releases the lever to which the cord is attached, so that it falls into the position shown by the dotted lines. The current now passes from C through the coils into the upper contact post, thence to the lever and lower contact post, which is connected to Z. The line is thus cut out and the bell continues ringing until the lever is raised by pulling the cord. As this arrangement, however, is rather uncertain in its action, unless very carefully

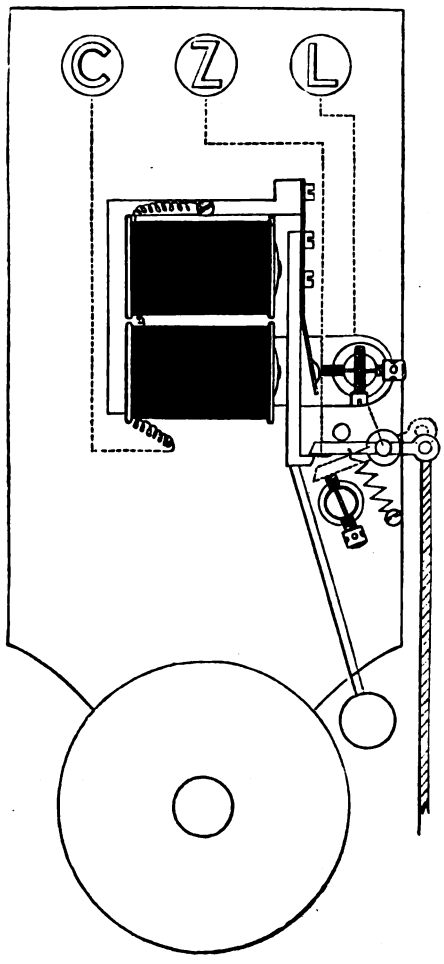

Fig. 6.

made, the arrangement shown by Fig. 7 is much to be preferred. In this case, when the push is pressed the current enters at C, thence through the coils of relay direct to line. This attracts the relay armature, causing the lever to fall against the upper-contact post The current then flows through the bell coils and lower contact, thence to upper contact and lever to Z. The bell continues ringing until pulling the cord raises the lever.

Pushes.—The variety of designs in pushes is numberless, but the principle is the same in all, viz., by the contact of a spring with another fixed or spring connection, as shown by Fig. 8.

In bed rooms a pear shaped push, depending from a silk cord, is often used, as shown by Fig. 9.

As, however, this form is liable to injury by violent use, many persons pulling at the cord as if using an ordinary bell, it is better to use a contact box, shown by Fig. 10, to which the ordinary bell ropes can be attached.

For front doors it is preferable to use pulls with the contacts arranged as shown by Fig. 11.

* For Article I. see *The Electrician* for May 14, 1886.

The use of ordinary pushes is open to several objections; the damp gets into them, causing rapid corrosion and swelling of the woodwork, and the button to stick in. Many persons do not understand the use of them, and lads of an experimental turn cannot resist ringing as they pass by.

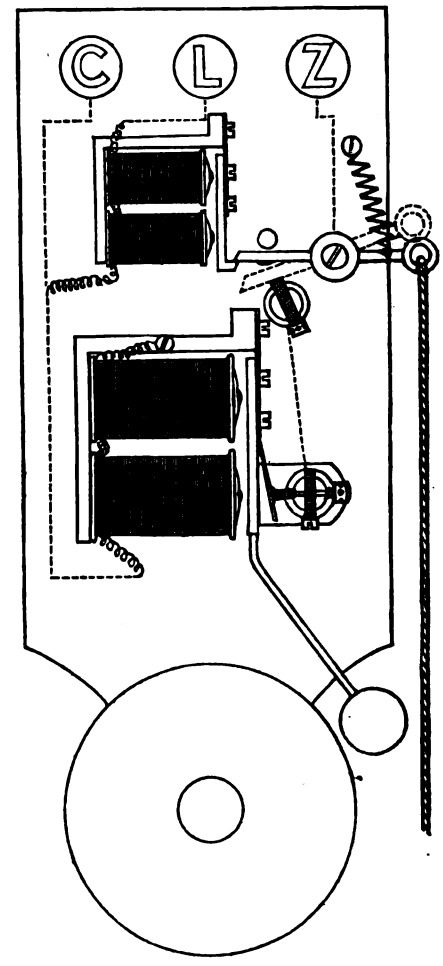

Fig. 7.

For insertion in floors under dining tables, &c., the form shown by Fig. 12 is very convenient; the covering in centre is made of rubber or leather.

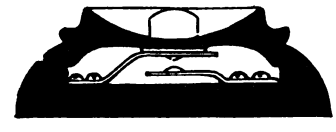

Fig. 8.

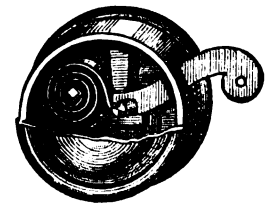

Fig. 10.

Fig. 9.

Sounder Pushes.—One of the usual complaints against electric bells is that no means exist of knowing whether the bell has rung after the push button has been pressed. Several attempts have been made to overcome this defect, but none of sufficient simplicity and cheapness to warrant their general introduction. The Mackenzie indicators recently introduced answer the purpose admirably. Their application to ordinary pushes is shown by 14 and 15.

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The mode of action can be readily seen by referring to Fig. 13. A is a soft iron core, fixed to an iron base, D, and surrounded by a bobbin of wire, which forms part of a circuit upon which the appliance has to be used. An iron box, C, is put over this electro-magnet, having the lid E close to the end of the core. Upon the current flowing round the bobbin the wire A and the lid E, being the respective poles of a continuous magnet, become magnetised with opposite polarities, and emit a sound which can be increased to any given extent, and which continues to be given out so long as the current is passing. This is the well-known "Page effect" made use of practically.

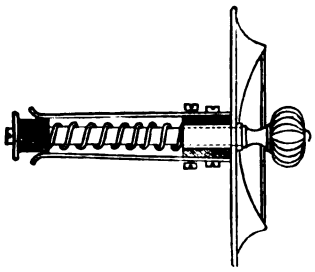

Fig. 11.

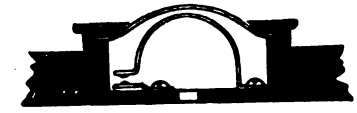

Fig. 12.

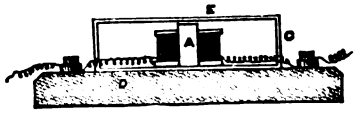

Fig. 13.

The action being solely molecular, no moving parts are needed, and therefore there is nothing to get out of repair; and, being an audible instead of a visual indicator, its use is not restricted to any place where light is required.

The apparatus can be adapted to any place where electric bells, &c., are used, and can also be made to take the place of a bell itself if required.

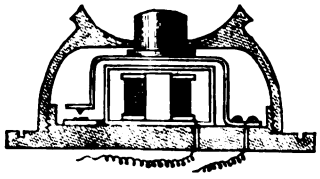

Fig. 14.

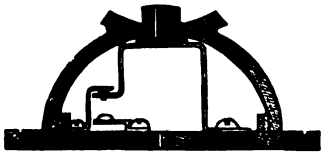

Fig. 16.

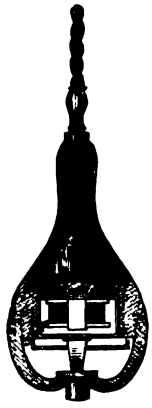

Fig. 15.

Key Pushes.—On lines where electric bell signals are both sent and received the form of push shown at Fig. 16 is used. When the push is at rest the spring is pressing against the contact *a*, or in connection with the bell *b*, but upon being pressed the spring comes against the contact *c*, which is connected with the carbon pole of battery, thus sending a current to ring the bell placed at the other end of the line.

ON THE WEBERIAN THEORY OF DIAMAGNETISM, AND On the Rotation of the Plane of Polarisation of Light by Magnetic and Diamagnetic Substances.

BY MISS J. M. CHAMBERS, B.SC.

The idea of supposing currents in molecules similar to those in conductors is due to Ampère. He, however, limited his ideas on the subject, as far as we know, to those permanent currents which are still called Amperian, and which, if his idea is correct, are the sole cause of the phenomenon known as magnetism. At that time the law of Lenz was not known, and I do not know whether electro-magnetic induction had ever even been observed. In Weber's theory of diamagnetism the idea of molecular currents is extended, and he deals with induced currents in them as well as permanent ones, these induced currents being produced in the same way and in accordance with the same laws as those in ordinary conductors. Faraday had a great notion of a molecular action of the medium in opposition to the theories then held of action at a distance. Maxwell's theory of light presupposes a "series of oppositely directed magnetisations and electromotive forces." In my conception of the idea of his theory (*Phil. Mag.*, Feb., 1886) I make the propagation of light depend on an action precisely like that which might be supposed to take place in a row of ordinary conductors. The object of the present paper is to extend this idea even further, and to bring into co-ordination the ideas of Ampère, of Weber, and of Maxwell's theory of light—that is, to take into account the interaction of the molecular currents presupposed in the three theories. I thus obtain a complete *explanation* of the rotation of the plane of polarisation of light in opposite directions by the two classes of substances. The experimental facts known are in complete accordance with these combined theories. Further, there is a crucial experiment, which has never yet been performed, by which the theory may be tested. If the result of this experiment is such as I expect, the probable nature of the action of the medium in electrical phenomena will be rendered clear. Of course we must consider the æther as the medium when no ponderable matter is present.

This combined theory makes the rotation of the plane of polarisation of light in opposite direction by the two classes of substances an argument in favour of Weber's theory of diamagnetism.

Ampère's theory may be extended somewhat. He supposes the molecules are circuits with electricity travelling round them in one particular plane. It is possible that currents may also be travelling round them in a perpendicular plane, but that the currents in one plane are stronger than those in the perpendicular one.

The effect of the molecular current, which is produced by the magnetic field in accordance with Lenz's law, and which by the Weberian theory produces diamagnetism, may be dependent on three things.

I. The strength of the original Amperian current in the molecules.

II. The resistance of the molecules.

III. The coefficient of mutual induction between each molecule and the field, which, if the field is uniform, is the effective area of the molecular circuit. In connection with this there is also the coefficient of self-induction of the molecular circuit.

I will call the strongest permanent current in the molecule the amperian current and the other permanent ones magnetic currents, as a distinction from diamagnetic currents, which latter are the ones produced in accordance with Lenz's law and Weber's theory.

Now, the Amperian and magnetic currents flow, we suppose, constantly for ever. We can hardly suppose there is a source of E.M.F. in a molecule, which would be equivalent to saying that matter could produce energy. Hence we must suppose that there is no resistance in a molecule, and, if this is the case for the permanent currents in it, we may suppose the same to be the case for all currents in it. Thus the effect of the introduction into a magnetic field on any substance, we will suppose, depends only on I. and III.

The current produced in the molecule in accordance with Lenz's law, that is, the diamagnectic current, depends on the effective area of the circuit. The effect of the self-induction of the current on itself will be that no lines of force due to the induction of the field will pass through the circuit. (See C. Maxwell, Vol. II., Art. 654.) The Lenz effect in ordinary conductors is transitory; but in a circuit of infinite conductivity it lasts as long as the force lines producing it fall on the circuit, and ceases only when they are removed. Since no force lines due to the induced current pass through the circuit in this case, it might be supposed that the action was confined to the external molecules; but there are the external force lines. Now, we do not suppose that the molecules fit into one another like bricks, but we rather suppose that there may be interstices between them. The external force lines of the diamagnetic currents will be of the same sign as those of field,

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and we may suppose that some of them pass through the interstices and strengthen the field for the molecules behind. In fact, the lines of induction pass outside not inside the molecular circuits on this theory. In the case of a diamagnetic, the interstices between the circuits will probably be as large as possible, because the smallest circuits in the molecules will tend to place themselves perpendicular to force lines. The field, therefore, for molecules behind the first row is that due to (I.) the Amperian currents in the molecules next them, the external lines of which are of course contrary to those of field, plus that due to (II.) the force lines of field which pass through the interstices, plus that due to (III.) the external lines of the Weberian or diamagnetic currents which pass through the same interstices.

Before proceeding further I will briefly state the theory which is, I believe, now most in vogue—that is, that whether a body acts as a paramagnetic or a diamagnetic, depends on whether it is more or less magnetic than the medium in which it is. The ordinary theory might be explained by supposing that all molecules had Amperian currents in them, but that these varied in strength, and that no Lenzian effects occurred in them at all.

The reason of a piece of soft iron setting lengthwise along the lines of force is given in "Deschanel," Art. 692. He ignores the medium altogether; but the argument will still be valid if we suppose the iron more magnetisable than it. In a similar manner, if the magnetism of the medium is stronger than that of the bar, we can show that the bar will place itself perpendicular to force lines.

Thus, suppose 1, 2, 3 three molecules of the bar rigidly connected together, and 4 and 5 two molecules of the medium. Since the magnetism of the molecules of the medium is the strongest, N_2 will be attracted by S_5 more than by S_1, and S_2

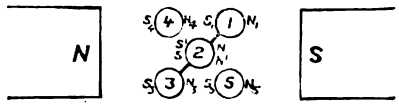

Fig. 1.

more by N_4 than N_5. Thus N_2 will tend towards N′ and S towards S′, which will cause the rod to turn more to the equatorial position, when the field is uniform, or nearly so. (Another theory by which a diamagnetic would also set with its long axis along lines of force in a uniform field is given by Deschanel. It ignores the medium and supposes the poles of a diamagnetic molecule in a reversed position to those of a magnetic one.)

I will now proceed to develop the Weberian theory.

When a substance is introduced into a magnetic field the molecules will tend to turn so as to place the planes in which are their Amperian currents perpendicular to the lines of force. The field will also induce currents in the molecules in accordance with Lenz's law. Owing to the tendency of the molecules to place the planes of Amperian currents perpendicular to lines of force, the diamagnetic currents will be formed in those planes in the first instance. Now, if the Amperian current is so strong that it outbalances the induced (or Weberian) current, the substance is magnetic. If, on the other hand, the Weberian current is greater than the Amperian, the circuit will tend to turn through a right angle. In doing this a Weberian current will be induced in a perpendicular direction, or at least in another direction. The amount of this current depends on the effective area of the circuit—that is, on the number of lines of field which are enclosed by circuit. In general, a molecule will tend to place itself with regard to force lines so that the greatest Amperian or magnetic current is perpendicular to them and the least Weberian or diamagnetic one, and the actual position taken up by it will depend on the resultant of the two actions. Of course there may be molecules with no Amperian currents, and in this case that plane of the molecule will place itself perpendicular to force lines in which its circuit has the least area. A penny between the poles of a magnet tends to place its plane along the lines of force simply because its area is least perpendicular to that plane. The Amperian current is independent of this area. When there are magnetic currents, which are insufficient to outbalance the induced ones, the matter will become more complicated. The molecule may have in any case no current at all perpendicular to force lines, an Amperian one or a Weberian one. We may have in a diamagnetic substance two poles joined by force lines as in a magnetic one, but in reversed positions. At the same time the poles due to the Amperian currents might have their joining line perpendicular to or in an oblique direction to force lines. The Weberian current depends on the effective area, but it also depends on the strength of the field. Hence the Weberian current will increase as the strength of the field increases. Hence it is possible to explain how a magnetic substance might become diamagnetic in a strongly magnetisable medium. The lines of force are drawn in by the medium, and the substance is consequently in a stronger field. Some recent experiments of Dr. Lodge show that possibly a substance which sets axially in a weak field may set equatorially in a strong one, the medium remaining the same (see *Nature*, March 25th). In such a case, of course, the medium might or might not remain magnetic. On this theory it does not seem impossible that the most magnetic substance might become diamagnetic if the field were sufficiently strong.

The reason of the setting of a magnetic substance, with stronger Amperian currents than those of medium, with its long axis along lines of force is explained in this theory as in the ordinary theory; so also the equatorial setting when the Amperian currents of the medium are the strongest. When the Weberian currents outbalance the Amperian the matter becomes more complicated. Probably, if both medium and bar are diamagnetic, and the bar the more strongly so, the setting would be again axial in a uniform or nearly uniform field. Of course there are several intermediate cases. Thus setting becomes no certain sign, whether the bar is magnetic or diamagnetic. I should think the rotation of the plane of polarisation of light the truer test, as will be seen from what follows.

The experiment of Beetz does not affect the theory, for of course the magnetic effect for a magnetic substance will be greatest when the planes of all the Amperian circuits are parallel.

I now come to the rotation of the plane of polarisation of light by magnetic and diamagnetic media, and this in conjunction with "A Simple Manner of Explaining C. Maxwell's Electro-magnetic Theory of Light" (see *Phil. Mag.*, Feb., or *Electrician*, Feb. 5, 1886) affords a plea in favour of Weber's theory.

Suppose we have a molecular circuit with an Amperian current travelling round it in the direction of the curved arrows. Suppose at the same time an E.M.F. to act which causes a straight current from A to B. Now, the current

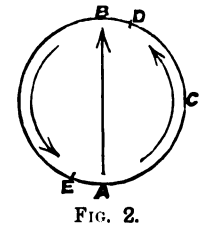

Fig. 2.

along A B will be attracted towards C all the time it passes upwards, in accordance with the general laws of the action of one current on another, and instead of reaching B we may suppose it arrives at some point, D. If now its direction is reversed, it will be attracted towards the opposite side, so that by one bob up and down it will reach E. The effect is that the general direction of the current is twisted through a certain angle. The amount of twist will depend on the strengths of the currents. This twist would be in the opposite direction if the circular current were in the opposite direction. Thus, the direction of rotation of the plane of polarisation of light depends upon whether the magnetic or the diamagnetic current is the strongest. This applies equally whether the direction of the E.M.F. or the direction of the magnetic force lines is the direction of the vibration which constitutes light, since the magnetic force lines always remain perpendicular to the current.

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I here suppose the same attraction to take place between the currents as would take place between the conductors carrying them if they were in separate conductors. I do not know whether this is a perfectly legitimate supposition, though I know of no experiment which either proves or disproves it. (The electric arc is drawn aside by a magnet; but, perhaps, here it is the particles of carbon bearing the electricity and moving with great velocity which are drawn aside.)

Thus the rotation of the plane of polarisation of light becomes the true test whether a substance is magnetic or diamagnetic, and the discrepancies experimentally found between the rotation of the plane of polarisation and the setting of a substance in a magnetic field are explained.

This theory also accounts for the double amount of rotation when the ray is reflected back along the same path. In the case of rotation in substances when there is no magnetic field the rotation is due to the difference of velocity with which the two circularly polarised rays, into which the plane polarised ray can be resolved, travel, as is plainly shown by Fresnel's experiment of the compound prism (*Annales de Chimie et de Physique*, 2nd série, Tome XXVIII., p. 147; *Œuvres Complètes*, Tome I., p. 731). This experiment is the following:—

A ray of plane polarised light, L R, falls normally on the first prism, and the two circularly polarised rays keep together in this prism. The prisms are of alternately positive and negative quartz, with the axis of crystal along the direction

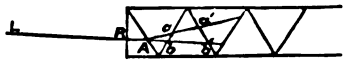

Fig. 3.

in which the ray passes. The second prism will act as if of denser medium for one circular ray, and of rarer for the other circular ray. Hence in the second prism the two rays become separated. In the third prism they are bent farther apart, because the action is reversed, and so on. It can be shown by the usual tests that the two rays are circularly polarised when they emerge from the compound prism.

The two circularly polarised rays are bent just as ordinary light is bent by an ordinary prism, and the bending in the former case, like that in the latter, must be due to change of velocity of propagation. When the rotation is due to molecular structure and the ray is reflected back, the rotation is destroyed, since, on the return passage, the direction of circular rotation taken with respect to the forward movement is reversed.

In the case of the quartz the vibration period and angular velocity in the two rays are the same, but their velocity of propagation is different in each prism. But there is another way in which the plane of polarisation might be rotated. The vibration period and velocity of propagation for both rays might be the same, but the angular velocity might be different in the two rays, and this is somewhat what I suppose to be the case in the magnetic field. The rotation in due to a totally different cause from that in the quartz. In the case of the rotation in a magnetic field a compound prism would *not* separate the two circularly polarised rays.

I have been told that the movement of a particle in a circularly polarised ray of light is very well represented by a corkscrew which we cause to rotate about the axis of the helix. If we mark a small spot on the corkscrew, this spot will simply appear to bob up and down when the line of sight is perpendicular to the length of helix; but will describe a circle when viewed along the length of helix. This supposes the period of the angular velocity to be the same as that of the transverse vibration. In this case the wave-motion along the direction of propagation is represented by Fig. 4. But it is quite possible to suppose the angular period different from the transverse period. In this case the wave-motion along the direction of propagation would be represented by such a figure as Fig. 5. There would, in fact, be a double period in such a case. I mention this to show that there are two ways in which retardation of one circular component on the other can take place.

It would be a curious modification of Fresnel's experiment to make the compound prism, instead of quartz of alternately positive and negative rotations, of alternately magnetic and diamagnetic media, and see whether the two circularly polarised rays could be separated. According to this theory they could *not* be so. The separation would not take place, because the retardation of one ray over the other is in the angular velocity, not in the velocity of propagation.

Fig. 4.

At present there are two points which go strongly to confirm the theory.

Fig. 5.

I. The *direction* of the rotation in each case is *correct*.

II. The amount of the rotation is doubled by reflection as the theory requires.

THE BRIGHTON ELECTRIC RAILWAY.

This line (particulars of which have appeared in previous issues of this journal) has been in constant operation over two years, and we now give some particulars as to the result of the working during this period. The line is rather under a mile in length, and includes some heavy gradients on sharp curves, the gauge being 2·9. The speed is limited to eight miles an hour, but a speed of over twenty-five miles has been obtained. The current is transmitted along the rails, which are fastened to wooden sleepers resting on the shingle, no special insulation being used. Each car seats thirty passengers, and the motor can draw another if necessary.

The plant comprises two cars fitted with motors; one 8 horse-power gas engine; one 12 horse-power gas engine; one Siemens D2 series dynamo; one Siemens D2 compound dynamo.

The working expenses for one year are as follows (average for two years):—Electrical machinery—new commutators and brushes, £10. 0s. 6d.; gas engines—refacing slides, &c., £6. 9s. 10½d.; oil and waste (that used for axles included), £10. 1s. 3d.; gas (including that used to light premises, price 3s. 3d. per 1,000 cubic feet), £114. 3s. 0½d.; attendant—52 weeks, at 18s., £46. 16s.; total, £187. 10s. 8d. The gross earnings per car mile are 1s. 7¼d.; the gross expenses (all renewals being paid out of revenue) 11⅛d.; car mileage per annum, 23,475; cost of haulage per car mile, 1·92d., barely 2d. (this includes the engine attendant).

Only one car is running, except on bank holidays, &c., on which occasion nearly all the power of the 12-horse engine is used. The repairs to the electrical machinery only amount to 5 per cent. per annum, and to the gas engine only about 2½ per cent. The only repairs to the electrical machinery of the two cars—the work having been nearly equally divided, each car having run about 25,000 miles—have been one new commutator and one spindle bush relined with soft metal; that, therefore, represents the wear and tear for nearly 50,000 miles running. The extra cost of running two cars is very slight, only about two-thirds more gas being required, and the other expenses being scarcely affected.

The above result must certainly be considered very gratifying, both to the proprietor of the line, Mr. Magnus Volk, and also to all those interested in electric locomotion.

Irregular Action of Galvanic Batteries.—Experiments have been made on the cause of irregularities in the action of galvanic batteries by H. V. Hayes and J. Trowbridge—*American Journal of Science*—by means of an apparatus for photographing the deflections of a galvanometer needle. The authors tested a number of batteries, all variations of current being accurately registered. Irregularities were found to be caused by two separate actions, a diminution in the current strength, caused by the pores of the partition becoming filled with the base, and secondly, a diminution of the acid at the positive pole. Both these difficulties are overcome by making a partition of as large surface dimensions as possible, and by using very porous material.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, *Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

VOLUME XVI.

Volume XVI. of "The Electrician," price 10s. 6d., is now ready.

Also cases for binding, price 2s.

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SPECIAL NOTICE.

THE PADDINGTON INSTALLATION.

A Supplement will be issued with our next number describing and illustrating the Paddington Installation of the Electric Light.

TELEPHONY AND TELEGRAPHY.

To those who are desirous of widely extending telephonic communication in this country Mr. W. H. PREECE'S discourse at the Society of Telegraph-Engineers last week affords very little material for consolation or hope. It is useful, however, as an explanation of some of the natural difficulties, and also of some of the artificial obstacles, which stand in the way of telephonic enterprise. As to the latter, the general cheering which greeted the lecturer's reference to "a grasping and selfish monopoly" showed pretty plainly that his audience understood the allusion, and endorsed the description. The charge was not pushed home with direct evidence or explicit reference to the offending monopoly, and in "another place" the cheering might have been—partly, at least—ironical. But as Mr. PREECE was scarcely likely to have thus designated the Department in which he himself occupies a high position, the inference is that he had in his mind none other than the UNITED TELEPHONE COMPANY, and evidently his audience so understood him. We should like to have seen the case substantiated with fuller detail, but apparently Mr. PREECE thought by contrasting the telephone in other countries with the telephone in this, and asking them to look on this picture and on that, his hearers would themselves draw the right conclusion as to who was responsible for the daub. We cannot pretend to supply the missing links in the chain of reasoning which led to a conclusion that the Company above referred to is wholly or greatly to blame in this matter; but some facts of common notoriety point in that direction, and we have on many occasions ourselves contended that the conduct and policy, if it has a policy, of the UNITED TELEPHONE management were shortsighted, oppressive, and indefensible. That it has kept in check the natural growth of the telephone there can be little doubt; and that it has done nothing, or next to nothing, in providing long-distance telephony is beyond all dispute.

As regards local telephony, the facts are too well known to need recapitulation. The Company has a monopoly, which it uses as monopol sts are apt to do when commercial considerations alone prevail unchecked by legislative limitations in the interests of the public. Its patents are of limited duration, it is true; but this is a circumstance which operates prejudicially against everybody but the proprietors. In this respect, however, the UNITED is on the same footing as the several other companies outside the Metropolitan area. Yet some of these companies have carried on their operations in a far more satisfactory manner, and in many instances have emulated the Post Office system in the neighbourhood of Newcastle by largely invoking the help of long-distance, or inter-urban telephony. That London and its neighbourhood are not well served is a matter of general complaint; and it is alleged that all attempts at improvement on the part of the POST OFFICE when appealed to by the public have been prevented by the refusal of the monopolists to allow any extraneous connection with their Exchanges. For obvious reasons the Government Department cannot enter into sharp competition with a private company, except at the instance of the public; and, of course, the first condition of such a demand is that every telephonic customer shall enjoy equal privileges, which cannot be granted if the company in possession shuts its system against all new comers. We regard this as a perfectly natural result of the situation, which was anomalous from the very first. Telephony, like Telegraphy, must be under one administration to be efficiently worked; and it unfortunately happens that if this one administration is not giving satisfaction, competition will provide no adequate remedy.

All this is extremely vexatious, no doubt, and it accounts for any strong language that may be used; but it has followed from the stupid outcry made against the Government when it endeavoured to acquire the same effective control over the Telephonic system that it already possessed over the Telegraphs. What it actually obtained was a pecuniary interest, which left it as impotent as ever; so that although the country had bought and paid for a monopoly which a judicial decision has since confirmed against the Telephone, the owners of that instrument are practically masters of its application to the wants of the country, and enjoy a monopoly which is worked solely for the profit of private individuals. In the United States this dilemma has been avoided by the virtual absorption of the one system in the other. Over a vast area of the States there exists a monopoly of the Telegraphs, which, though in private hands, resembles for practical purposes the State monopoly here. To prevent friction between the rival systems, and to enable the telephone to benefit by existing telegraph lines, a working arrangement has been come to which virtually makes the two

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systems one. In Belgium, too, where long-distance telephony has made considerable progress, the State, which owns the telegraphs, has taken the former under its sole control, leaving the town telephones in the hands of private companies, but under rigid conditions which enable the two to work into each other's hands. The connection between the Exchanges and the trunk lines is complete in the places we have named; but this is not the case in England; and one explanation of the fact, no doubt, is the commercial instinct, to use no harsher term, of the UNITED TELEPHONE COMPANY.

From all we hear of the commercial aspects of long-distance telephony, it does not seem to be a paying business even in countries where telegraphy is much slower than in this, except as a means of feeding local Exchanges. In spite of the singularly artificial—we had almost said artful—means employed in America to raise money for erecting trunk line telephone wires, they do not pay; and the statement that 150 telephone conversations daily are held on wires between Antwerp and Brussels seems to us to indicate that ordinary telegraphic messages must travel rather slowly in Belgium. Be that as it may, however, it obviously will not pay the Telephone Companies in this country to erect long trunk wires for the telephone alone; nor, on the other hand, could the Post Office afford to allow its wires to be used in competition by the Telephone Companies. Even were this difficulty got over there is, as Mr. PREECE explained, the electrical one, which is not to be overcome without crippling the telegraph service for the sake of a subsidiary, and, it must be confessed, comparatively unimportant adjunct. To attach the necessary appliances for making telephony and telegraphy possible on the same or closely contiguous wires would immensely reduce the efficiency of the Telegraphs. And here we come to a fact which perhaps more than any other has conduced to stay the advance of telephony generally in this country. We have a telegraph system which, in point of equipment, comprehensiveness, efficiency, and high speed, is such as no other country in the world can boast of. To all intents and purposes users of the English telegraphs—at all events between large centres of industry and commerce—do daily hold constant conversation by telegraph. The telephone would be as superfluous as it certainly would be invidious and costly. It found us in this condition, and the truth is it could not better the existing means of communication. It has its own peculiar province, no doubt—but a limited one at the best; and although much, very much, remains to be done, and done, too, in a far better way than at present, the universal extension of the telephone is a dream, which cannot be even partially realised until the system falls into the hands of one controlling or State-regulated administration.

CORRESPONDENCE.

THE POLARITY OF TADPOLES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With reference to the experiment made by Prof. L. Herman in connection with the above subject, which was reported in your issue of April 23rd, the following explanation of the phenomenon has presented itself to my mind. As soon as the current was made, the tadpoles all turned towards the anode and soon became motionless. This seems to me to show that what took place was exactly similar to the application of the positive pad to the human subject, as described by Dr. Vigouroux in his letter to your journal on April 30th. He says that the positive pad must be held by the operator, while the negative pad may be held by the patient.

In this case the water was the agent of both operator and patient. In short, according to my view, this is only another example of the hypnotic effect of the electric current.—Yours, &c.,

TÊTARD.

London, N., May 19th, 1886.

SCHANSCHIEFF'S SINGLE LIQUID BATTERY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am somewhat surprised that no mention has been made in *The Electrician* of Schanschieff's remarkable single liquid battery. A long and costly experience with primary batteries justifies me in saying that this is the most satisfactory and convenient yet invented. The liquid is an acid solution of sulphate of mercury, and from the sediment deposited by one gallon of it after use in a battery I recovered, by the simple process of squeezing through wash leather, 1lb. 10oz. of pure metallic mercury. The E.M.F. is quite constant until the solution is nearly exhausted, the reduction of the mercury being gradual and regular, while the zincs are of necessity kept bright and well amalgamated.—Yours, &c.,

G. CHRISTOPHER DAVIES.

Orwell House, Norwich, May 15, 1886.

MESSRS. GOOLDEN AND TROTTER'S LARGE DYNAMO.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Will you permit us to say, with reference to a paragraph in last week's *Electrician*, that the large* dynamos made by Messrs. Goolden and Trotter for the "Mersey" and "Severn," will not be driven, as stated, by Willans "six-cylinder compound engines," but by engines of the type known as "central-valve receiver engines." These are made under a recent patent of Mr. Willans, and are designed expressly for cases where extreme economy of fuel is required — as it naturally is on board ship, when dynamos are kept running day and night for incandescent lighting, and are not merely run occasionally for search lights. These engines are double-tandem, *i.e.*, they have two cranks, with high and low pressure cylinders to each, and variable cut-off gear. In justice to your informant, it should be added that Messrs. Goolden and Trotter are also supplying for the same ships two smaller dynamos, which are driven by three-tandem Willans compound engines of the type no doubt referred to as "six-cylinder engines"; but the dynamos actually referred to in the paragraph are, we believe, those driven by central-valve engines.—Yours, &c.,

WILLANS AND ROBINSON.

Thames Ditton, 18th May, 1886.

A STUDY OF INDUCTION.

BY SAMUEL E. PHILLIPS, F.C.S.

The following remarks were penned as a sequel to an extended examination of Prof. Gordon and Clerk Maxwell's views upon induction, and the electro-magnetic theory of light. They are now offered in an *inquiring* rather than in a dogmatic spirit:—

In aiming at clear thoughts and precise definitions, may we say that induction consists of 3 kinds?

(1) *Static induction* subsists wherever high tension effects are produced by frictional machines or otherwise, and the lines of force or polarity are either straight or more or less radiant, as dependent on conditions well understood.

As these static effects can be produced with high tension batteries where circuit or voltaism is prevented, so it is extremely probable that they subsist in more or less appreciable degrees wherever the + and − elements of chemistry evince a strain or tendency to combination.

(2) *Magnetic Induction* is familiarly known in the phenomena of magnetism. A moot question of very great interest occurs here, as to whether the lines of force of (1) and (2) are iden-

[* These should have been described as small dynamos compared with their large output.—ED. *E.*]

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tical, or what is the *rationale* of their different behaviours. Let A B be the opposite plates of a condenser, and N S the opposite poles of a magnetic system.

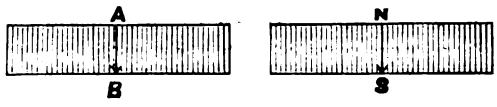

Fig. 1.

As to the similarly direct character of the lines of force in both cases there can be no question whatever. They both form, under similar conditions, radiant or curved lines. In both cases the opposite poles are attracted with a force varying as the square of the distance apart, the deviations from this law being similar in both cases.

Assuming that A is + and B −, does it also follow that N is + and S − ?

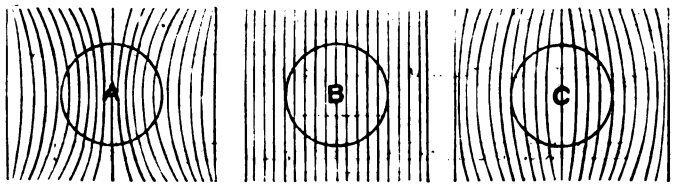

Fig. 2.

In A we have a good conductor, and the lines of force are diverted and condensed therein, the effect of which is to hold it strongly in the axial position as between two poles; it involves stable equilibrium. In B the lines neither condense nor open out; its conductivity is just that of the medium; and hence no outward manifestations of property. In C we have a bad conductor, and the lines of force are diverted and condensed in the medium, involving unstable equilibrium, with a tendency, if of more linear form, to be pushed aside or into a transverse position. A is called a para-magnetic, and C a dia-magnetic, and associated with these unfortunate terms a huge structure of wanton hypothesis has darkened the path of sound inquiry. This, however, needs a separate treatment; but it may be well to note in utmost brevity that Faraday, working with media of varied conductivities, and tubes of iron solution of varied strengths, showed that para- or dia- properties could easily be foreseen and produced accordingly, and Messrs. Gladstone and Tribe have subsequently elucidated the same principles of action in the liquid field of electrolysis, where suspended insertions of better conducting material than the medium have a stable equilibrium for the axial position, while worse conductors are pushed aside into the lines of weakest force, and behave precisely as dia-magnetics.

(3) *Electro-magnetic Induction* chiefly refers to that static or polar condition which surrounds every current of flowing electricity.

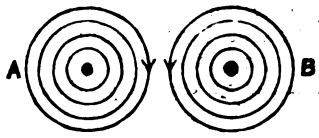

Fig. 3.

In A a positive current is supposed to be going down or away from the observer, when the lines of force or magnetism are directed as the hands of a watch move, viz., to the right. In B the current is reversed, or is supposed to be coming up, and the direction of the lines of force is opposite, or to the left.

It is a pure convention that the lines of force should be represented as going out of N and entering S, where it should always be clearly understood that in both cases there is no going out or motion at all under uniform conditions, the effect in both cases being a purely static one. In the magnetic case the direction, force, and character of the lines of force are familarly appreciable by placing or oscillating small magnets in the field.

In the electric case magnets do not so point, and the properties of the system are determinable by an electrometer.

In both cases, if air be the medium, there is no retentiveness of the polarity; but with rigid steel the retentiveness is very great, just as with rigid glass in the other case the polarity is considerably retained, and the residual discharges would be more prolonged if the medium were thicker.

In both cases the lines of force behave similarly with different media. In other words, they are dependent on rates of conductivity. In the electric case taking air as standard or unity = 1, then the conductivity of shellac for this polar force is 2, or double that of air. But there is considerable vagueness as to the methods of obtaining these determinations.

Mr. Gordon, with Clerk Maxwell, estimated "double extra-dense flint glass" to be 3·838; but Dr. Hopkinson well maintains that its capacity, or, as I prefer to call it, its conductivity, is nearly tenfold that of air.

In the magnetic case this vagueness is yet more predominant, and the phenomena is *so relative* that absolute determinations are a great mistake. But the fundamental facts are simple and familiar. Bismuth possesses the lowest conductivity; but that varies greatly under different conditions. Air is a better conductor, and iron enormously the best. In principle diagram 2 applies to both lines of force; but it is more usual to regard them from the magnetic point of view.

Here we have several conventions which are purely such; but they are necessary and very convenient. Of course the setting up of these curves tends to produce an opposite current in the wire, involving a counter E.M.F., or increased resistance during the variable period; and *inversely* on stopping the current, the fall to zero of these magnetic lines induces in the wire an "extra current" in the same direction as that which produced the system. These are not opinions, but facts which can easily be verified. This inductive action admits of being increased in two ways—firstly, by self-induction, and, secondly, by increasing the conductivity of the media.

By self-induction we mean that increase of inductive effect, inherent upon a condensation of the magnetic field, when the wire, instead of being straight, is wound into a coil, and the convolutions are allowed to act upon each other. It is easy to see that this proximity of convolutions in the same wire must increase the counter E.M.F. we have described.

I feel justified in making no comment on the Hughes research, because some high authorities have maintained that it leaves intact the previously established "electro-dynamic laws." Mr. O. Heaviside says: "I have failed to find herein any departure from the known laws of electro-magnetism." But I cannot help remarking that throughout the discussion the utmost vagueness has subsisted in the use of terms. As the word "self-induction" had a previous existence, such as I have described, *if* Mr. Hughes has added another element, it seems more feasible to have called it *internal induction*—an action in the substance of the wire, as distinguished from that of the surrounding media. Secondly. By increasing the conductivity of the media, we greatly enhance the inductive effect. We first of all have an inherent inductivity in the wire, or, more correctly, in the current passing along the wire, because the same thing equally subsists in the battery fluid; then we find an increase by winding the wire into a coil, so as to make an air magnet; and, last of all, a greater increase of the force, by placing iron in the coil. Using the conventions before referred to, we can now see that a right-handed spiral conveying a positive current from A will produce a S pole at the nearest end thus

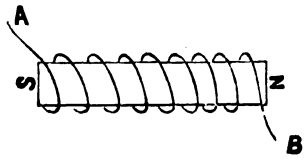

Fig. 4.

We have said that setting up this polarity induces a counter E.M.F. against the current; but, as this cannot be directly recognised, we now essay to prove the fact. Let the two ends

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A and B be connected through a galvanometer, and the N S polarity be induced by a stronger external magnetism; we then find a current induced in the wire, in the contrary direction to that which would have induced the given polarity; and further, on the sudden withdrawal of the constraint, the fall of this polarity to zero will induce an opposite current in the wire, viz., the extra current of Faraday.

In place of the present vagueness it is high time that we should have some strict, or, at any rate, approximative measurements of the "variable period," say, in a mile of aerial wire; and, secondly, of the percentages of elongation due to the wire being coiled round an air magnet, and also with iron core; and, lastly, the length of this period in, say, a mile of submerged wire. I know of no one better fitted for the accomplishment of this work than Mr. Willoughby Smith, who, probably, has all the materials necessary for a definite determination. This brings me to my last point, viz., What is the nature of the induction in a submarine wire?

It is a complex of (1) and (3), and, strange to say, it is mostly (1). We cannot utterly exclude (3), because "electromagnetic induction" is but another term for "current induction;" but this affection with its directive tendencies is minimised by a thin field of dielectric, and it is immensely overpowered by No. (1), or static induction, with a non-directive accumulation. It is popularly and very properly considered a condenser; but it has this difference, that the conducting wire, or circular plate, is very elongated, and the charge set up thereon varies as the potential at any given distance from the source of power.

Given two small condensers, of similar capacity, one charged to one volt and the other to two volts potential, we then find that the quantities of electricity charged upon these similar surfaces will be as one to two, and precisely thus it is with a submarine condenser. Let us assume a potential of 10 volts at one end, and zero, or earth, at the distant end.

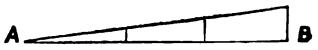

Fig. 5.

It then follows, if we divide this length into equal parts, that the geometrical areas of tension will be as 1, 3, 5, 7, &c.; and that at any given instant of charge the quantities of electricity held or induced in these sections will be as 1, 3, 5, 7, &c.

There is a curious distinction between the induced transverse or right-angled lines of force (3), and the direct lines of static induction (1). The former are irrespective of tension or potential, and only dependent on the quantity of electricity flowing, whereas the latter are wholly dependent on potential. The magnetic induction along the line A B is a constant at every point, and we may have a parallel circuit with 10, 100, or 1,000 times the quantity of electricity flowing, as is familiar in a Bridge circuit, but if the two be connected at points of equal potential, no current will flow from the many to the few lines of force, or from the strong magnetism to the weak; and, conversely, may we not say that the static lines of force will be the same in both circuits, from the same source, though one may carry 10 amperes and the other 1,000?

SMOKE CONDENSED BY MEANS OF ELECTRICITY.

From Tyndall's experiments on the dust found in the air, Messrs. Clark and Lodge observed that a body at a higher temperature than its surrounding medium is enveloped in a thin stratum of air absolutely free from dust.

Dr. Lodge, of Liverpool, conceived the idea of studying this phenomenon, making use of electricity; he remarked that electrical discharges produced at high tension by a statical machine possessed the property of condensing dust and smoke of all kinds.

This was not slow in finding a ready application in metallurgy, for condensing the dangerous fumes and dust of lead in the factory of Messrs. Walker, Parker, and Co., one of the largest of its kind in England. The results secured were remarkable, and the attention of students was particularly called to this new method of treatment, because it had a twofold bearing—on the health of the workmen and on the economy of the process.

The experiments of Dr. Lodge are of that class which will in time become classical, and which should be made public. It was with this object that the two devices illustrated (Figs. 1 and 2) were constructed. The larger apparatus is designed to show the effect of electricity upon smoke in motion (Fig. 1). It is provided with a furnace, in which may be burned the materials for producing the smoke. The fumes first pass into a box having glass sides, which enable us to see what is going on inside. This is connected with another box of the same kind by means of a horizontal glass tube. The second box has a tube at its top and a device for regulating the draught. Each of the boxes in its opposite sides is provided with brass combs, which are connected with the opposite poles of a Toepler-Voss, a Ramsden, or Holtz electrical machine.

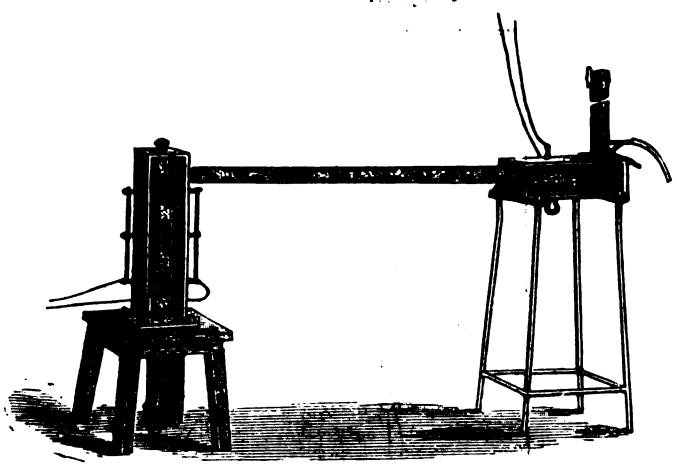

Fig. 1.—Large Apparatus for Condensing Smoke by Electricity.

German tinder, for instance, is put into the furnace. The thick smoke which it produces passes through the whole apparatus. If the electrical machine is now put in motion until the sparks pass between the combs, immediately the smoke becomes agitated, and in a little while will disappear by condensation. The boxes and tube become as transparent as before the experiment. The smoke of German tinder can be advantageously replaced by that which is produced by the combination of hydrochloric acid and ammonia. The white thick smoke of hydrochlorate of ammonia condenses very rapidly on the electrified combs.

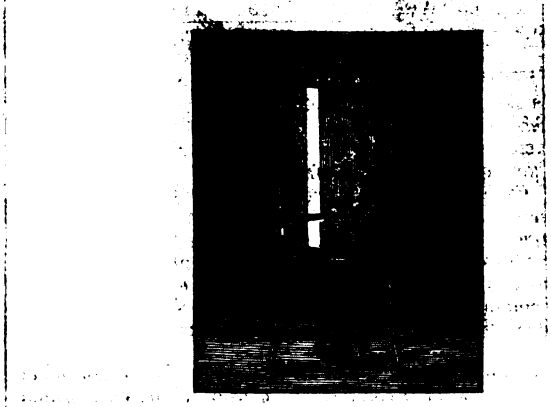

Fig. 2.—Small Apparatus for Condensing Smoke by Electricity.

The smaller apparatus (Fig. 2) is much more practicable for experiment. It shows the effect of electricity on smoke at rest, and gives a clear idea of the phenomenon. It consists in a glass cylinder having openings in its side, through which are passed the metallic combs. It is mounted on three feet, and is provided with the furnace for producing the smoke. The draught is maintained through the tube in the top of the chamber. Paper treated with nitre or German tinder is burned in the furnace, or else the vapours upon which the experiment is to be made are liberated by some chemical reaction. When the glass cylinder is full of smoke, the machine connected with the combs is put in motion, and the vase, smoky and cloudy, immediately becomes clear and transparent, the vapours being condensed. Tobacco smoke is very quickly and easily condensed by means of this machine.

These phenomena are remarkable. They appeal at once to the savant, the artisan, the student of hygiene, and demonstrate how infinite is the field of discovery.—Gascon Tissandier in *La Nature*.

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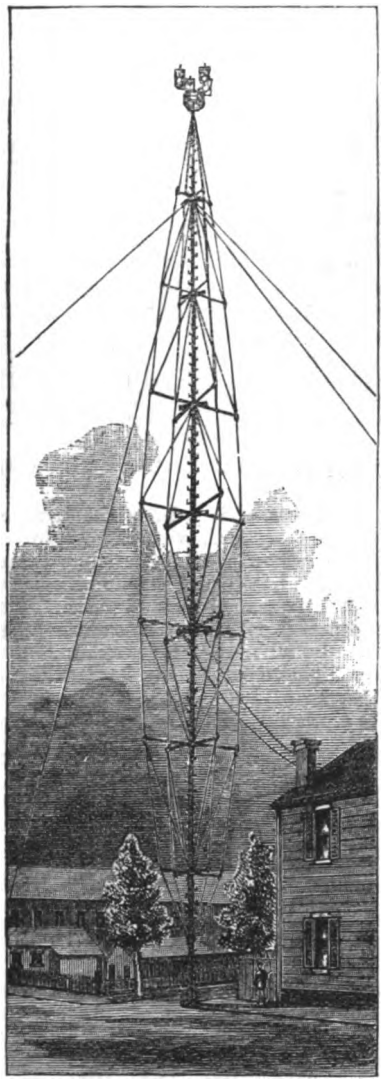
A NEW ELECTRIC LIGHT TOWER AND IMPROVED DYNAMO.

City lighting by means of arc lamps placed upon towers seems to be gaining favour very rapidly, especially in our Western cities. The placing of a number of powerfnl lamps in elevated positions has the advantage of distributing the light more evenly over a larger area than would be possible with a similar number of lamps near the surface. Taking into consideration, also, the fact that the cavity formed in the upper positive carbon causes a large portion of the light to be projected downward in the form of a cone, it is apparent that with lamps near the surface the immediate vicinity of the lamp post receives the most intense light, to the detriment of the illumination of outlying space.



The introduction and use of tower structures has been somewhat hindered by the materially increased first cost of plant consequent upon their use, and by the obstruction of the streets by the foundations and lower framework of some of the early forms of these towers.

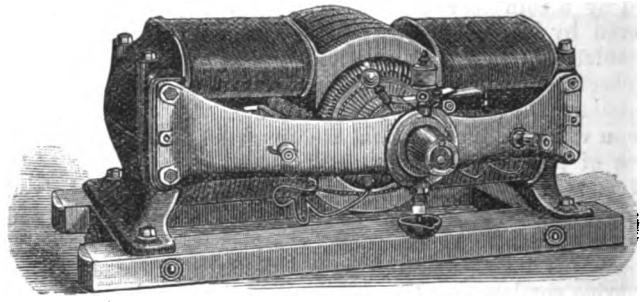
Notwithstanding these hindrances, the tower system has grown rapidly in public favour, and there are now in use in this country nearly three hundred electric light towers, with a fair prospect that the number will be largely increased before the close of the present year.

Among the towers of recent design is the one illustrated in the accompanying engraving, devised by Mr. P. S. Adams, of the Jenney Electric Company, of Indianapolis, Ind. The height of this tower is 125ft., and it is designed specially for strength and to prevent the obstruction of the streets. People are learning that the additional first cost of plant, with towers, is much more than compensated for by the superior quality of the light and by the increased area illuminated thereby.

The tower illustrated in the above engraving is, as stated, 125ft. in height, and embodies numerous improvements designed to cheapen the processes of manufacture and erection, to give strength and beauty to the structure, and to leave the streets clear for traffic. The lamps are supported in iron frames, mounted upon pivoted arms extending from the railing posts of the trimmer's platform. This arrangement greatly reduces the amount of wind surface at the top of the tower, and of shadow at its base, permits the use of any desired number of lamps, and adds materially to the appearance of the structure. The tower structure consists of a central vertical mast, in 16ft. sections, trussed by horizontal struts and vertical and diagonal brace rods or ties. It is supported by means of guys of galvanised wire rope, connected to suitable guy posts, firmly set at the kerb line of the side walks, the whole forming a trussed structure of great strength and neatness.

The Jenney Electric Company, of Indianapolis, has also lately made several improvements and changes in the form of its dynamo, which we illustrate below as it now appears. As will be seen, the arm which carries the armature consists of a rigid casting extending from end to end of the field-magnets, and bolted to the latter at their neutral points. This construction permits of the use of long overlapping field-magnets, without entailing the use of a needlessly long armature shaft.

Another feature in this construction is the fact that the greatest strength of the arm lies in the direction of the pull of the belt. Fitted in these arms are self-adjusting swivel-boxes or bearings for the armature shaft, provided with sight-feed, automatic oil cups, so arranged that each drop of oil fed to the bearings can be seen, thus enabling the operator to be sure whether the bearings are being lubricated or not.



The boxes themselves are babbited and reamed out to an accurate size, are interchangeable, and can be removed from the machine and replaced without disturbing the armature or removing the arm. *Electrical World.*

ELECTRIC LIGHT IN THE SUEZ CANAL.

A correspondent of the *Daily News* writes the following account of the passage of the Peninsular and Oriental Company's steamer "Carthage" through the Suez Canal at night by means of the electric light, which is a much fuller account than has before appeared:—

"Soon after our leaving Malta it became evident preparations of an unusual kind were being made. A large iron tank was brought up from the hold; coils of wire lay about; lamps with a more powerful lens than usual, and various gear not often seen on board ship were produced. The ship's carpenters were busy making what appeared to be a miniature platform; while the noise of the hammer and rush of steam disturbed the usual quiet. Then for the first time the announcement was made that it had been decided to attempt to make the passage of the Suez Canal at night by means of electric light, and some preliminary experiments were to be made in order to test the electrical gear taken on board in London. After trying the dynamo and engine the most important point was to decide upon the best place to fix the projector. Experts are not agreed upon this; and unfortunately the roughness of the sea did not admit of a trial being made with the light low down in front of the stem—the position Captain Hector thought most suitable. Up to the present all vessels passing through the canal have been compelled to tie up at sunset, and remain moored to the banks until sunrise. The actual channel being so narrow it would be impossible for steamers of deep draught to steer correctly in an uncertain light. The directors restrict the hours for transit to the daytime, and thus have kept the water-way comparatively free from accidents. Delay was inevitable, and was shared by all alike. Recently the Board of Control so far rescinded this rule as to permit steamers properly fitted with electric light to pass through at night. Months passed before any of the shipping companies availed themselves of this facility, until the Peninsular and Oriental Co. decided to make the experiment, and fixed upon this magnificent steamer of 5,000 tons burden as the pioneer, and gave Captain Hector a free hand in regard to all arrangements. Port Said was reached at 5:30 p.m. on the 22nd inst., where most of the canal authorities from their headquarters had come down to wait our arrival. It had been doubted whether it was practicable to navigate a large vessel through the winding parts of the canal by an artificial light, so that many of the officials were anxious to watch this first trial. M. Desavery, chef du service; M. Rumeau, sous chef; Captain Tillier, and eight of the senior pilots joined us at Port Said. All the gear had been got into position ready for use. An engine of 12 horse-power had been fixed near the forecastle, and a stage of about 4ft. by 6ft. swung over the

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bows and lashed about 14ft. above the water. The projector was fixed about the centre of the platform, and placed under the charge of the electrician in chief and a seaman. The engine and dynamo were worked by the assistant electrician and an engineer. Each side of the steamer carried an electric lamp, to be used in case of need, and another was hung over the stern. About 8 p.m. everything was in readiness. The light was tested for about ten minutes, and the current found to be steady and continuous. Crowds of dark faces from the banks and from other vessels curiously watched the novel sight as the huge steamer, throwing forward a dazzling light, quietly slipped from the mooring buoy and slowly made for the head of the canal. The cross lights from the shipping and town must have been disturbing to those who were piloting us, especially as a steamer right ahead hid the entrance from view. After passing it we saw that the two buoys that mark the entrance to the canal had been lighted, to prevent any difficulty in finding the channel. The full efficiency of the light was not apparent until the glare of the town had been left behind; then it was found the illuminating power was such that the buoys could be distinguished more than 500 yards ahead. Light was also needed close to the vessel, and the arc of dispersion was arranged to include the buoys within a few feet of the bows; at a slightly increased distance the rays extended to the banks. In portions of the canal where the banks are high the dry white sand threw back upon the water the spreading rays, perceptibly increasing the illuminating power. For the first hour there was no moon; subsequently the light was a doubtful advantage. In the early hours of the morning a dredger, not showing the regulation lights, occasioned a considerable delay. Perhaps the most difficult part was steering a vessel 430ft. long, drawing 24½ft. of water, between the high banks and sharp curves just before Ismailia, in a channel not more than 80ft. wide and only 26ft. deep, solely by means of a light projected from the vessel itself. By forethought and skilful pilotage it was accomplished without an accident of any kind, and it proved the wisdom of the captain's determination to make the trial with one light fixed low down on the stem, instead of placing it on the foreyard or having one on each side. Ismailia, situated about half-way through the canal, was reached soon after five in the morning. Daylight was available for the rest of the distance, and the steamer anchored in Suez Harbour soon after 2 p.m. on March 23. Thus the actual passage of the Canal was made in eighteen hours, but when the two hours' delay are deducted it leaves sixteen hours for actual steaming. All travellers to India, China, and Australia will appreciate the immense saving in time thus effected, and in times of quarantine in Egypt the mails will be passed through with much less delay. The complete success of the trial has convinced the Canal authorities that the largest vessels can, under efficient management, be navigated at night. Few steamers make the passage under two days, but by the enterprise of one of our leading shipping companies and by the skill of their officers it has been conclusively demonstrated that at least a full day can be saved by Eastward bound vessels."

THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

The meeting of this Society, after the Easter recess, was resumed on Thursday evening, 13th inst., at the Institution of Civil Engineers, Gt. George-street, Prof. HUGHES in the chair. It was announced by the Secretary that a petition had been presented to Parliament embodying the views of the Society with reference to the Electric Lighting Act Amendment Bills now under discussion, namely, that no Act of the kind would be deemed satisfactory which did not place the electric lighting industry on the same footing as gas lighting.

Mr. W. H. PREECE, F.R.S., then delivered an address upon "Long-Distance Telephony." First explaining that although his subject was one dealing not so much with the problem How far can we telephone? as with the question How much we can telephone? between places widely apart, and on purely commercial principles, Mr. Preece intended to confine himself mainly to trunk wire working as distinguished from local working. Long-distance telephony in America was called "extra-territorial," meaning beyond the boundary of concessional rights of the various companies. It was also called "toll line" work, meaning that conversation could be held by telephone on payment of a toll, as distinct from the system of subscription applicable to local telephony. In Belgium the system was called inter-urban, a very good designation, which would apply very well to this country also. How far commercially a success wherever it had been tried was a doubtful matter, although indirectly no doubt it had been found worth while to introduce and extend it. The difficulty attending it was not one of apparatus. But, as a matter of fact, very few improvements—except in switches and bells, which he was not then considering—had been made in telephonic appliances on the original Bell receiver first brought to England by him (Mr. Preece), and scarcely any in the microphone transmitter invented by the Society's president. Different tunes had been played with these great inventions, but all upon the old strings of Bell, Edison, and Hughes. And with regard to Edison, ingenious as his devices undoubtedly were, those that had come into practical use were based on Hughes's discovery, not on the Edison patents. Many had been the inventions, so called, and patents without number, and the cry is still they come; but there was hardly anything novel about them, and nothing that was commercially valuable. The apparatus actually in use was sufficient for its purpose provided it was properly worked, and the wires attached to it erected with due regard to the indispensable conditions of telephonic working. Yet it was undoubtedly the fact that in this country there was nothing like the amount of long-distance telephoning that prevailed in the United States and on the Continent of Europe. And the progress of telephony in general was also far greater elsewhere than here. In the States at the beginning of 1877 there were no telephones on hire. Before the end of that year there were 780. In 1880, only three years later, there were 60,800 telephones in use, and 100 exchanges. In 1883 the number of telephones had increased to nearly 250,000; and at the end of last year the total had reached 325,750, and there were 782 exchanges. In Canada similarly, where there was a population of under three millions, no fewer than 18,000 telephones were on hire. Compare these figures with those for England, where in December, 1885, only 13,000 telephones had come into operation. In the capitals of Europe the same contrast appeared. Berlin stood at the top with 4,248 subscribers; whilst London with its enormous population had only 4,103, and barely exceeded Paris with 4,054. Even the small city of Stockholm possessed 3,825 telephone subscribers; whilst Liverpool, Glasgow, and similar places in England numbered about 1,100 each. It is, therefore, evident that from some cause or other telephony has made not nearly the progress in England that it has in other countries. [Here Mr. BRIGHT interjected "Charges;" an explanation which Mr. PREECE rejected, pointing out that the charges were actually less in this country and the restrictions fewer than in the States.]

Coming now more closely to the subject of telephoning over long distances there was, he said, no serious difficulty attending it considered as a mere electrical problem. On first bringing over the Bell telephone to this country, he tried it with success through 60 miles of cable between Dartmouth and Guernsey; afterwards on the longer cable from Holyhead to Dublin; and he well remembered on that occasion the late Mr. Sanger, when asked "Can you hear my voice?" replying quite distinctly, "Yes, and smell your cigar!" Further experiments proved, however, that upon a cable of the pattern of the Atlantic ones, 20 miles was the limit to which intelligible speech could be carried on. Lord Rayleigh has since confirmed this conclusion on theoretical grounds. With land lines, however, far greater distances have been traversed. In Persia they had conversed at a distance of 390 miles; in India at 500 miles; and in America 1,000. It was therefore not, he repeated, a question of apparatus, but of the conductor and its environment. The lecturer then described in detail all the known forms of inductive and other disturbances to which telephone lines are liable, especially when in contiguity to telegraph wires, or to electric lighting wires in towns; all tending to blurr the sounds of telephonic articulation, enfeeble, and finally obliterate them. And this it was important to observe happens on short circuits as well as on long ones. Audible disturbances are easily eliminated. The Post Office had effected this by employing metallic circuits of twisted wire. Nevertheless, we cannot speak beyond certain distances. At Newcastle they had gradually increased the limit of commercial working to 20 miles with underground wires. Thirty-nine miles had been spoken through, but ordinarily 20 miles was the limit. As regards overhead wires, the Post Office had erected four wires from London to Liverpool and Manchester; they were No. 8 iron wires, and on the twist principle. They worked well for a limited distance; at 150 miles the articulation was not satisfactory; at 170 it was possible to speak, but not commercially practicable; and at 200 there was nothing but low rumbling sounds. Since Prof. Hughes's paper on this subject, it appeared that had these wires been of copper, speech would have been practicable throughout the whole length.

Reverting to the commercial aspects of inter-urban telephony, Mr. Preece described the system as worked in America and Belgium, the latter on the Van Rysselberghe plan, which has been fully explained and illustrated in these pages. The single wire system prevails in the States, as is evident from a comparison of the mileage of poles and wires. A toll of 25 cents. is charged for five minutes' conversation. He had found by personal trial of some of these lines that they did not all work satisfactorily. Between Chicago and Milwaukee this was the case. Between Michigan and Boston, a far greater distance, the speaking was good, but this was a metallic circuit of copper wires. A curious plan for obtaining capital to erect these inter-urban lines had been resorted to in the States. Toll tickets are sold beforehand, and as soon as the required amount has been raised in this way the work is completed and the purchasers of toll tickets are, of course, entitled to expend them in conversation, which accordingly they do without stint. Notwithstanding this artificial aid to long-distance telephony, the result is not particularly encouraging as regards customers, and it certainly does not pay except indirectly by attracting subscribers to the local exchanges. Here in England the United Telephone Company had only one trunk line of this kind, that between London

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and Brighton. Outside the influence of this powerful company, however, in Lancashire notably, a great number of such lines had been erected, as also in Scotland. These lines were said to be doing a fair business. But the most complete system was to be found in Belgium under the management of the Government. who had left local telephony to the operations of private companies. Van Rysselburghe's method had been introduced there, and had eliminated induction or rendered it innocuous. The sudden rise and fall of current in Morse signalling were slowed down by inserting condensers and electro-magnets, so that they do not appreciably disturb the telephone. The inventor appeared to have got the idea by observing that the telegraph signals from Brussels to London had a bad effect on telephone lines, whereas those coming from London were harmless. Every circuit in Belgium is, therefore, armed with these anti-induction appliances, and the result is that even busy circuits are available for inter-urban telephony, it being practicable to carry on the two operations on the self-same wire. France has partially adopted this system, which has probably a great future before it on the Continent.

Now, why, it may be asked, cannot we do the same thing here? Firstly, because every circuit so armed is a cause of retardation, which matters little on circuits working slowly, but becomes serious when a normal speed of 250 or 300 words a minute gets reduced to, say, 150. Such would be its effect on fast-speed working in this country, and we cannot afford to sacrifice speed in telegraphy for the minor advantage of efficiency in telephony. Then, secondly, there are the independent railway telegraph systems over which there is no Governmental control; and, lastly, there is no sufficient grounds for supposing that the inter-urban system, even if practicable, would be a commercial success. Mr. Preece then described the Post Office idea of telephony as exemplified in the admirable network of communication established at Newcastle and neighbourhood by Mr. Heaviside. Double wires are employed, and are worked on what is called the "bridge" principle. Government telegraphs as such are not liked by some people, but he claimed for the Post Office a preponderance of improvements, and the contrast which England presented to the rest of the telephoning world was due to the crushing and grasping monopoly chiefly of one great private company [loud cheers]. Its patents, however, would expire in due time, and the existing hindrances to telephonic progress would then be removed.

Mr. Van Rysselberghe offered, with the approval of the Society, to bring before its notice a full description of his system on some future occasion. He might mention, however, that besides the great successes it had achieved in Belgium and France, the results of practical trials over far greater distances in America were most encouraging. He found that iron wires were worthless for distances over 150 miles; all the high notes were reduced to bass, and the sibilants consequently lost. On copper covered steel wires, 1,000 and 2,000 miles long, articulation was perfect. Each country had no doubt its special local conditions to be considered; but as regards the commercial aspect of the question he believed the system would pay, and cited the case of Brussels and Antwerp, between which places 150 telephonic messages passed every day. In the course of his observations Mr Van Rysselberghe claimed for an Englishman, the late Cromwell F. Varley, the distinction of being the first inventor of the telephone.

Prof. Silvanus Thompson repeated his previously-expresssed opinion that the great defects of our telephonic systems were the over sensitiveness of the receiver, the feebleness of the transmitter, and the low resistance of the wire. He thought that two of our countrymen in Canada had gone a very great way towards solving the problem of long-distance telephony.

After some remarks from Mr. Blakesley, Mr. W. H. Preece having briefly replied, expressing his dissent from the opinions of Prof. S. Thompson, the proceedings terminated.

PROF. FORBES' CANTOR LECTURES.

(Continued from page 523.)

LECTURE III.

In my last two lectures I spoke about statical electricity and about a current of electricity, and I mentioned that there was a time when it was absolutely necessary to prove that these two manifestations of electrical influence were identical. Now, there is no doubt about it. We know that statical electricity and dynamic electricity are identical; that there are not two kinds of electricity, but that the phenomena we studied on the occasion of the first lecture and the phenomena we considered on the occasion of the second lecture are really different manifestations of one identical force. To-day I am going to describe to you some of the principal phenomena of magnetism, and we shall find that here also we are dealing with simply another manifestation of this same electrical force. The latest development of the theories of magnetism, in fact, do actually go to prove that magnetism is simply due to a large number of small electrical currents. But about that we shall be able to say something more towards the close of the lecture. The facts in connection with magnetism which were known in days of old were very limited indeed. In fact, it seems remarkable that the discovery of the mariner's compass should have been delayed to so late a period in the world's history as it was. In various parts of the world occasionally pieces of mineral, largely composed of iron, are found which have this peculiar property—that when suspended by means of a thread they point in a north and south direction, if they are not disturbed by the presence of other pieces of iron in the neighbourhood. Here is a piece of loadstone which is marked at the two ends with a blue and red mark to show the extremities of the axis, which must be made horizontal. Then, suspending it by a thread so that the axis remains horizontal, we see that the main direction of the loadstone from one pole to the other remains in the magnetic meridian—that is to say, in a north and south direction. There is another property in connection with the loadstone, which is this—that two different pieces of loadstone influence each other, that they produce a movement of attraction or repulsion. Thus, when I take a piece of loadstone, and bring it into the neighbourhood of another which is suspended, you see it immediately turning round, showing that there is an influence between the pole I presented to it, and the pole of the suspended magnet. I have commenced these remarks by speaking about the loadstone, because that is really the commencement of where we find our magnetism. But in our experiments which we may perform in the laboratory, instead of using pieces of natural loadstone such as are found already magnetised, it is much more convenient in general to use a magnet such as I have here [shown], and which I can suspend upon a pivot. A needle thus magnetised will set itself naturally in a north and south direction, and can be acted upon by another magnet brought near it so as to cause repulsion between the two similarly coloured poles. We shall likewise have attraction between the red pole of one magnet and the blue pole of another. These bars of magnetised steel have been marked so that the red end points towards the north, and this is what we have arrived at by this experiment, that we show that the two north ends of the magnets repel each other, and the two south ends repel each other, but that the south end of the one attracts the north end of the other. This is generally expressed by saying that like magnetisms repel each other, and unlike magnetisms attract each other. I have been speaking about the north end of this needle, and as there is some confusion in naming these poles it would be right to say when I speak of the north end of the compass—the end of the needle or magnet—I mean the end nearest to the north. It has been sometimes thought advisable to call the north end of a compass needle the other end, because in all probability the earth acts as a huge magnet, in which there is one kind of magnetism more prevalent in the northern hemisphere, and one kind more prevalent in the southern hemisphere, and it has been proposed by some that we should call that the north kind of magnetism which is in the northern half of the earth. There has been a great deal of controversy about what is the right terminology to use, and Sir William Thomson has said it is impossible to instil into the head of the ordinary investigator that the north pole of the earth has south magnetism in it. But it has always seemed to me much more difficult to instil into the head of the ordinary seaman the idea that the north end of the compass needle has south polarity; and I think it really seems more advisable to speak about the north end of the compass needle as being the end which points towards the north. We have arrived, then, at this general result, that the north end of a magnet repels the north end of another magnet, and that the south end of a magnet repels the south end of another, but that the north and south mutually attract each other. This action between a suspended magnet and another magnet is identically of the same nature as the action which takes place between the whole mass of the earth and a suspended needle. A suspended magnet tends to place itself in a north and south direction, the reason being that the whole earth acts in the same manner as this magnet which I hold in my hand does. When I hold a magnet near a suspended magnetised needle it tends to give a certain direction to the needle. The action of the earth is of the same nature, and it is due to the fact that the earth is magnetised as a whole, or that there is a sufficient quantity of iron in this magnetic condition in the earth, that we have the most valuable property of the compass needle, viz., that it points north and south. It was noticed in the seventeenth century that there is another action due to the earth's magnetism besides the attraction of the magnetic needle into a north and south position. It was noticed by Norman that if we take a bar of steel pivoted accurately at its centre of gravity, so that it ought to naturally rest equally in every direction, then the end which points to the north will also incline downwards at a considerable angle, and here I have such a needle, which I place in the magnetic meridian fairly suspended on the pivot, and free to take up any position in the magnetic meridian. That compass needle, as you will notice, points at a very great angle—something like 70 degrees—to the horizon. This is spoken of as the dip of the compass needle. Gilbert, who was the father of the science of magnetism, wrote a great deal about this, and pointed out that the dip of the needle might be explained simply by supposing that the earth was acting as a magnet. Gilbert said, "If we have a magnet going through the earth, or only a short magnet at its centre, it will attract the suspended magnet, and the tendency will be for the magnet placed in the equator to rest horizontally." But if we were to bring the same needle up to, say, the latitude of London, then the end of it, which was attracted by the pole of the magnet in the centre of the earth, would point downwards. Therefore, we should have the compass needle, when suspended at the centre of gravity, not lying horizontally, but dipping down towards the horizon, and this will explain the dip of the needle, namely, that its attractive action is due to the magnetised portions of the earth. Gilbert had no more knowledge about dip than the fact that in these latitudes the dip was about 70 degrees. But he saw, if his explanation was correct, that the dip would vary in different parts of the earth, that at the north pole of the earth the needle would dip vertically downwards, that at the equator it would be parallel to the horizon, and that the inclination would gradually change from the vertical to the horizontal as we passed from one of the poles to

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the equator. This was a prediction by Gilbert, which was completely verified when the experiments were made in different parts of the earth. A spot near the North Pole, where the dipping needle is perfectly vertical, has actually been visited by Arctic explorers. When I was speaking to you about a statical electrified body, I told you that there were two kinds of forces that come into play. One was a true force, which caused a motion in a material body; the other was not what Newton would have called a force, because it did not produce a motion in the body, but produced a motion of electrification. That force we call electromotive force, and electromotive force produces a change in the electrical condition of bodies. We have an exactly similar thing in the case of magnetism. Whenever there is a magnet in the neighbourhood of any point of space it is producing a force of this peculiar kind—not only a force that will produce motion in a body, but a force tending to produce a rearrangement of the magnetic condition. We shall see a little more clearly how this acts presently. But as we study the question of magnetism more fully we shall find that all the magnetic phenomena are produced by the action of forces which are able to rearrange the condition of magnetism in iron bodies, and those forces are trying to change the condition of magnetism in those iron bodies. If the bodies offer a sufficiently small resistance, then the change in the condition of magnetism can take place. If they offer a large resistance the change cannot take place. But the analogy is most remarkable between that which we might call magnetomotive force, and what we have spoken of as electromotive force. The resistance which iron or other bodies oppose to a rearrangement of the magnetic state is exactly analogous to the resistance which is offered by different materials, either conductors or non-conductors, to a rearrangement of the electrical condition when a body is subjected to the action of electromotive force.

(To be continued.)

LEGAL INTELLIGENCE.

The Edison and Swan United Electric Light Company and others v. Woodhouse and Rawson.

The trial of this important patent action, which occupied the whole of last week, was continued on Saturday and Monday. The action was originally based upon three patents, but has been considerably narrowed, there being, as the Judge thinks, no evidence to go to a jury as to the infringement of Swan's patent and the minor patent of Ginningham. The trial, as now narrowed, chiefly relates to the second of four claims in a patent of Mr. Edison, dating from November, 1878. The first claim is for a lamp with a filament of carbon of high resistance, made as described, secured to metallic wires as set forth. The mode of securing wires described in the patent has been superseded. The second claim is for "the combination of carbon filament" (not, it is to be observed, as in the first claim made as described) "within a receiver made entirely of glass, through which the leading wires pass, and from which receiver the air is exhausted for the purpose set forth."

Counsel for the plaintiffs are Mr. Aston, Q.C., Sir R. E. Webster, Q.C., Mr. Moulton, Q.C., and Mr. P. Edward Dove; for the defendants, the Solicitor-General (Sir Horace Davey, Q.C.), Mr. Charles, Q.C., Mr. Macrory, and Mr. H. G. Rawson.

Dr. FRANKLAND, the first witness for the defendants, was examined on Saturday by Mr. Macrory. He was taken through the several patents relied on as anticipations, beginning at King's patent in 1845 for an incandescent lamp by means of a carbon burner in a Torricellian vacuum. He considered the chief difference between the older attempted lamps and Edison's lamp, as described in principle, was that the older lamps had not globes entirely of glass, and thus failed because other events in science, such as the invention and improvement of the dynamo, had taken place since. He gave results of his own in producing carbon filaments by coating a strip of boxwood with thread and paper according to Sidot's process, by which he produced a flexible and uniform carbon filament instead of the unevenly coated filament that Prof. Dewar had produced. He had worked, he said, with a hydro-carbon that contained comparatively little carbon, under 40 per cent., while Prof. Dewar employed benzine, which contains over 90 per cent. His process occupied three hours, while Prof. Dewar's occupied only one.

The cross-examination of Dr. Frankland by Mr. ASTON, Q.C., which had begun on Saturday, was completed to-day, and he was re-examined by the SOLICITOR-GENERAL.

Principal Jamieson, of Glasgow, in his capacity of a practical electrician, was examined by Mr. MACRORY, cross-examined by Mr. ASTON, Q.C., and re-examined by Mr. CHARLES, Q.C., and the examination in chief of Dr. Odling by Mr. CHARLES, Q.C., was commenced. Principal Jamieson gives it as his opinion that some of the prior specifications gave a sufficient description of how to make as good a practical carbon glow lamp as Edison's, which he considered was imperfect. He said that there was not enough in the specification to tell a practical workman how to get a proper carbonised filament for the purposes of glow electric lighting, though he agreed with Dr. Frankland that a filament would be properly carbonised according to Sidot's process, which was published in 1870, but that was not known to an ordinary workman. He also said the platinum wires, which are sealed through the glass receiver or lamp, would only at that time be sealed in a manner that would not stand long enough under the strain of change of heat to be commercially successful; and, in the third place, that Edison's description of how to make a lamp was insufficient, inasmuch as it did not direct the workman to "run on the pump" while making the vacuum. He said the knowledge on the subject had not advanced sufficiently to make a really good lamp till about the end of 1880, a year after Edison's patent in question was provisionally taken out.

The trial was continued on Tuesday. The evidence of Dr. Odling, the third of the defendants' expert witnesses, was completed. Mr. Rawson, one of the defendants, was examined. He said their lamp contained a carbon burner of small sectional area, the method and process of preparing which was a trade secret, the maintenance of which was essential to their successful manufacture. He said it was made under a process discovered since the date of the plaintiffs' patent.

The SOLICITOR-GENERAL very shortly summed up his case. He dealt with the second claim of the Edison patent of November, 1879, the trial having been almost narrowed to the consideration of that claim. It is for the combination of "a carbon filament within a receiver made entirely of glass, through which the leading wires pass, and from which receiver the air is exhausted for the purpose set forth." The Solicitor-General said that either "filament" must be construed in the less natural sense of a carbon filament made according to the mode of manufacture described by Edison, and in that case there was no infringement, or if, on the other hand, the word was to be construed as meaning any filament, considering the state of knowledge with respect to electric lighting at the date of the patent, the claim was too wide.

Mr. Justice BUTT asked whether it would be advantageous that he should try the other action between the same parties relating to the Cheeseborough patent. He said it was exceedingly inconvenient that a judge of the Probate Division, in which there are only two judges, should continue to sit outside his division, and the fortnight for which he was to sit had already expired.

Counsel on both sides agreed that though the Cheeseborough case was entirely different it was comparatively short, and much time would be saved by its being heard by a judge who had already acquired so much knowledge of electric lamps.

His LORDSHIP said he would consult with the President of the Division, and settle by Wednesday whether he could go on.

Mr. ASTON, Q.C., commenced his reply, which he continued on Wednesday till the Court rose at half-past 3. He proceeded to give the history of the various attempts that had been made prior to the date of Edison's patent to make a successful incandescent lamp by such men as Roberts, Scott, Harrison, Lane-Fox, Van Choate, and others, but without success, and pointed out that the first time the word "filament" was used was on the 1st of July, 1880, a year after Edison's patent was provisionally taken out. He then went on to prove that Edison, until the 17th of June, 1879, had not succeeded in re-introducing the discarded carbon, because up to that time it had not struck anybody that it was necessary, when they dealt with carbon, which was a most refractory material unless its properties were known, to give to it those properties which were possessed by metallic wires before they could solve the problem of getting an incandescent lamp. What was the property required to guard against the inconvenience arising from rigidity, the inconvenience arising from instability, and which always arose when at one time they had a cold temperature, and at another an intensely heated temperature, as was previously experienced? It was obtained by putting the carbon in a glass vessel connected with platinum wires in the form described by Edison. Carbon was readmitted after it had been rejected by Edison as late as the 17th June, 1879, as being the only medium which was suitable for the purpose intended, but in the particular form in which he used it. In other words he (Mr. Aston) contended that up to the date of Edison's patent carbon had been rejected by everybody as useless for the purpose, and was reintroduced by Edison to public notice in a particular form, and in the only form in which it was capable of being used, according to the evidence adduced before the Court. He asked his lordship whether it was not true that there were certain advantages new to this form of using the carbon which restored it to the favour of electricians after it had been rejected by them, and which entitled the plaintiffs to say that there had been an infringement in their patent. He next proceeded to quote a number of precedents which had a legal bearing on the present case, and said that the combination which was here claimed was a new combination. It was a new carbon conductor, which was put into a lamp new in form, new in character, and new in the advantages which it presented. It was true that Edison described in his specification the various modes of manufacturing his carbon filaments, but in his provisional specification, to which he was obliged to adhere, Edison did not make the manufacture of the carbon filament part of his invention. He contended that there was nothing which the patentee ought to have described in his complete specification of the 10th November, 1879, which had been omitted, or which invalidated the claim he now set up. The invention consisted of improvements in the lamp, not so much in improvements in the method of making the filaments for the lamp.

Mr. JUSTICE BUTT, in giving his judgment, said: The plaintiffs in this action complain of an infringement of the three patents relating to the construction of an electric incandescent lamp. The first of those is that of Mr. Edison, which I will describe later on. As I understand the matter the principal feature of Mr. Swan's patent is a process by which he proposed to make and maintain nearly a perfect vacuum in a globe. Mr. Ginningham's patent is one for fixing the carbon burner of an incandescent lamp to platinum wires. The defence consists of a denial of the validity of the patents, and a denial of the infringement. As to Mr. Swan's and Mr. Ginningham's patents, I intimated at an early stage of the proceedings that there was no evidence of such infringement, and I understand that that view has not been since seriously contested. The question, therefore, of validity of these two patents becomes for the present purpose immaterial. Now, with reference to Mr. Edison's patent, which is a patent of the 10th of May, 1880, there is one fact which is either admitted or beyond contest in this case, and

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it is that before the date of the specification in question no good and efficient incandescent lamp was made or known. The invention which Mr. Edison claims has been compendiously stated by Sir Frederick Bramwell in his evidence, and he states it in these words. He is asked by Sir Richard Webster this question. "(Q.) Of course the construction of the specification is entirely for my lord, but would you suppose it was only for the purpose of pointing to previous knowledge that the combination you find described there is an electric machine or lamp? (A.) I find the vessel entirely made of glass, containing a carbon filament attached to the contact wires, which wires are sealed through the glass. I find that this vessel is to be exhausted of its air to a very great degree, the patentee mentioning that one millionth of the atmosphere may be attained. The patentee says that with a lamp of that construction light can be obtained by rendering the filament incandescent by means of an electric current." That is his account of the invention, and I adopt that account, and I adopt it without the slightest hesitation, because it is not a matter which depends on my own judgment. It was accepted by all the scientific witnesses called by the defendants. It was accepted in terms by Dr. Franklin, and the other gentlemen on the same side stated that they all agreed with his evidence. And that is the invention for the infringement of which these plaintiffs, who are owners of the legal and beneficial interest of this patent, 4,576, are now claiming an injunction and damages. As I have said, the defendants deny the validity of the patent; they also deny its infringement by them. I think it will be convenient to deal with the latter question first. I have all along been clearly of the opinion that there is no proof of an infringement of the claims Nos. 3 and 4 in Mr. Edison's specification. Those claims are as follows:—"No. 3. A coiled carbon filament or strip, arranged in such a manner that only a portion of such carbon conductor shall radiate the light, as set forth. No. 4. The method herein described for securing the platinum contact wires to the carbon filament, and carbonising the whole in a closed lamp, substantially as set forth." I now think, whatever may have struck me in parts of this inquiry, that there is no infringement of claim No. 1, and I shall be prepared so to hold if necessary. Claim No. 1 is in these words:—"An electric lamp for giving a light by incandescence, consisting of a carbon filament of high resistance, as set forth." But in the view I take of claim No. 2 this question becomes important. Now, the question of the infringement of claim No. 2 depends upon the meaning to be attached to the words in it, "a carbon filament." If these words mean a carbon filament made as described in the patent, I should hold that there was no proof of its infringement. But I do not so interpret these words. I hold them to mean any carbon filament, however made, which possesses certain qualities or properties mentioned in the specification, or necessarily resulting from the description there given. To answer that description the carbon filament must, I think, possess flexibility and resiliance. It must be of small cross section offering a high degree of resistance to the passage of an electric current, and it must present but a small surface from which radiation can take place. I am disposed also to think (but on this I refrain from giving a decided opinion) that the degree of resistance must not be less than 100 ohms, as mentioned on page 3 of the specification. Taking the above to be a correct interpretation of the words "a carbon filament" in Claim 2, it is clear that there has been an infringement of the patent by the defendants. Without stating the evidence of all the plaintiffs' witnesses it will suffice to read a part from that given by Mr. Rawson, one of the defendants. Now, in the course of his evidence Mr. Rawson states as follows:—"We have used carbon filaments connected at the ends with platinum wires in a vessel made wholly of glass; practically, the leading wires passing into and from the receiver are sealed into the body of the glass vessel, and the air is exhausted so as to get as good a vacuum as we can. We use that combination with the object of getting a good incandescent lamp, and in that incandescent lamp we use a carbon filament that is flexible, and as stable at high temperature as we can get it. We do not use Edison's process for the purpose of making a filament. What we do is in substitution of this process. Our process of making and preparing the carbon filament is superior to Edison's." That is his evidence, and, as I have said, the interpretation I have put, rightly or wrongly, upon the words "a carbon filament" in claim No. 2 shows that there is an infringement of the patent, applying that interpretation to it. But it is said, "even so, assuming the infringement, the defendants are not liable in this action, because the patent is invalid," and I will deal as well as I am able with the various arguments with which they maintain such to be the case. It is not always easy to separate in matters such as this that which the counsel have argued from that which some of their witnesses have said, and it may be in stating the objections I shall in one or two instances rather deal with the evidence of some of the witnesses than with the Solicitor-General's arguments. I am, of course, anxious not to put anything into his mouth which he did not express. At the same time there are one or two points in which I think the witnesses went beyond what he has argued. Of course, if he had given up the point expressly I should not refer to it. Now, the first reason, as I gather, in support of the invalidity of this patent is this:—It is said that a carbon filament, when taken to mean that which I have held it to mean, is a description too vague and indefinite—or, to use the Solicitor-General's words, too large. That is an argument to which I cannot accede, for I see no reason why a carbon filament having the properties mentioned in Mr. Edison's patent, in which the patentee tells the public how to make it, may not properly be the subject of a patent so that it is capable of being made by methods and of materials other than those set forth in the specification. This observation certainly does not lose any of its force when the question is not the thing patented, but only one of the several parts of a combination patent. Secondly, it is said (I am not professing to put the arguments in the order in which they were given) that the specification is not such as will enable a competent workman to make the lamp. The plaintiffs' witnesses have stated that in their opinion it would enable him to make the lamp. I use the word "lamp" for the moment apart from the question of a good lamp. We have had an expression of opinion from several of the plaintiffs' witnesses to that effect. I find that Dr. Odling, when he comes to be cross-examined on the subject, says what I am going to read: "Mr. Edison having first applied the filament conductor to an incandescent lamp, any competent electrician could make, by the description in Edison's patent, the carbonised filament there described. Geissler's vacuum tubes were perfectly well known in England. They were wires sealed through the glass. Sealing through the glass was a perfectly well-known operation to electricians. A competent electrician would want no other directions as to sealing the wires than Edison gives in his specification. A competent electrician would have no difficulty in properly exhausting the globe from Edison's specification." I take that as being very strongly in favour of what plaintiffs' witnesses have said, and I hold, therefore, that that evidence itself would be sufficient to warrant us in supposing that the specification in question is one which would enable a competent workman to make a good lamp. But, then, in the next place, if I understand it, it is said that a lamp made according to that specification would not be a good lamp. So say some certainly of the defendants' scientific witnesses. But there is evidence from the plaintiffs' witnesses to the contrary. And, moreover, the Solicitor-General expressly stated that he did not dispute the utility of Mr. Edison's invention. Under these circumstances I come to the conclusion that a sufficiently good lamp may be made by a competent workman from the description given in Edison's specification. It was said (and at one time I was strongly inclined to agree with the suggestion) by the Solicitor-General that the patent was invalid, because at the time of the final specification Mr. Edison himself knew of a better method of making a filament, and in support of that proposition his provisional specification of the 15th Dec., 1879, No. 5,127, was referred to. Now the date of that provisional specification, it will be observed, is subsequent to the date of the specification which we are now considering, which is the 10th of Nov. preceding. It was many months prior to the final specification we are considering, and therefore it is perfectly true to say that at the time of the final specification Mr. Edison knew of another mode of manufacturing his carbon filaments. The Solicitor-General said a better mode. Perhaps he is warranted in that. I am not prepared to deny it. Therefore the argument is, he ought to have disclosed it in his final specification, because a patentee is not entitled on the authorities, and as a matter of good sense he is not entitled, to withhold from the public a matter the discovery of which he was aware formed an important integral part of the provisional specification of his patent, and then take out another patent afterwards for that. What this would do would be to put the public, or those who deal with such matters, to the inconvenience and expense of taking out a licence to use two patents, whereas they ought to have the benefit of the whole by taking out a licence for one. It must, however, be borne in mind that Mr. Edison does not claim in his patent 4,576 for the manufacture of carbon filaments. His claim is for the union of carbon filaments possessing certain properties with other parts of his combination. There is no evidence that at the time of filing his provisional specification 4,576, he had discovered or knew of the process in patent No. 5,127, and I agree with Mr. Aston that an inventor has no right to put into his final specification as part of his invention a discovery which he had not made at the time, and of which he was ignorant when he filed his provisional specification. I think, therefore, the contention on this head cannot fall against the plaintiffs. But, further, it is alleged that the invention was not new, and this is a part of the case that has occupied the greater part of our time. It is perfectly true that a number of specifications anterior to Mr. Edison's patent have been adduced, describing either the separate parts of Mr. Edison's combination or something very like them. Without losing sight of the others, I refer specially to those of Mr. Lane-Fox, Mr. Pulvermacher, Mr. Sidot, and Mr. Swan. But no one of these publications, unless it be Swan's, contains the combination described in Mr. Edison's patent 4,576. That I am right in this I think must appear from the evidence generally. Well, now I will refer to the anticipations put before me. I do not propose to go through these publications in detail, but a good example of them, I think, may be found in the patent of Mr. Pulvermacher. It is said that that is a clear anticipation, at all events, of claim No. 3 of Mr. Edison's specification. It is perfectly correct to say that we have in Pulvermacher's specification a description of a carbon rod or thread which, if taken by itself, is very like Mr. Edison's coiled carbon filament mentioned in Claim 3, taken by itself. But it is used by Mr. Pulvermacher in a totally different way and for a totally different purpose. As I understand, Mr. Pulvermacher's specification was to be applied not to an incandescent lamp but to an arc light, the spiral in question was to be coiled round the inner core, also of carbon, there being insulation between the two. It was not to be attached to wires at both ends. Of course that would be inconsistent with the notion of an arc light. Curiously enough Mr. Pulvermacher's claim deals with two modes of lighting—the arc light and the incandescent light. It is very remarkable that, having described in detail this spiral rod or thread for the purpose of his arc light, when he comes to state what his mode of procuring an incandescent light is, he discards his carbon conductor altogether and resorts to metallic wires. Whatever likeness there may be between Mr. Pulvermacher's spiral rod and Mr. Edison's coiled carbon filament, mentioned in Claim 3, it is perfectly clear to my mind that Mr. Pulvermacher was wholly unaware that a coiled thread of carbon could be applied to the purposes of incandescent lighting, because if he was aware of it he would not discard it when he came to make his incandescent lamp, which is provided for in the very same patent. I am almost afraid to attempt another reference

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to Dr. Odling's evidence, but I think that I have the passage under my eye. "Lamp E F 3 could not be made from Pulvermacher's patent, nor from anything known prior to Nov., 1879, except Mr. Swan's lamp, which would enable a competent electrician to make one." "But whence would he get the direction which would enable him to make the filament?" "I think I have got it from Pulvermacher's specification, but I find that is not so." "Anywhere else?" "I do not call to mind that there is. For Pulvermacher's purpose, the spiral must be of considerable size and thickness." So much for the alleged anticipation by Pulvermacher. With regard to Mr. Lane-Fox, I do not think it necessary to go at any length into a description of his proposed lamps or systems of lighting. It seems to me that the Solicitor-General was perfectly warranted when he said it was quite clear the different specifications of Mr. Lane-Fox that he had realised and knew all the elements that were necessary to make a good incandescent lamp. I will illustrate what I mean by one example—the necessity of a high degree of resistance. I think these observations were perfectly warranted, and it is true that as I have followed them when he comes to prescribe what he would use for the purpose of his own invention, Mr. Lane-Fox nearly always seems to revert to a metallic wire for a conductor, and not to a carbon thread. He does mention in one of his specifications a carbon conductor; but then, as I understand the matter, when he comes practically and finally to deal with the subject he disclaims it, and it drops out of his patent, evidently because he did not know how to make an efficient carbon conductor. He says it was less desirable than the metal under all circumstances, and he did not know how to make one which would be better. I now come to the alleged anticipation by Mr. Swan, and it seems to me that his lamp is the only combination at all like that of Mr. Edison. Other inventors, other men of science, may have described individual parts of the combination, but none of them have brought these parts into combination as Mr. Edison has done. I think it is clear that each individual part of the combination may have been known before, yet if the combination of those parts be new, that combination may very properly be the subject of a patent. But it does appear to me that if Mr. Swan's conductor was practically the same thing as Mr. Edison's carbon filament, then we have in Mr. Swan's lamp and in Mr. Swan's lectures, I think, the whole of Mr. Edison's combination, and that before the date of Mr. Edison's specification. The main question, therefore, is:—Are Mr. Swan's carbon rod or pencil and Mr. Edison's carbon filament the same thing? Now, I think they are not. It is a question of interpretation, and *primâ facie* no doubt the meaning of the words in a written contract is for the judge, but where technical terms, words of art, are used, the evidence of scientific witnesses and experts to explain the sense in which they are used in their opinion may be received. Accordingly each side has called a certain number of scientific witnesses, to whom have been put questions as to the meaning of the words "a carbon filament" in claim No. 2. It is said that in the multitude of counsellors there is wisdom, but when those counsellors turn out to be equally divided in opinion, and when it turns out that the only point on which they agree is that they agree to differ, I do not see how the judge derives very much benefit or advantage from their evidence. In fact, such is the case here. The witnesses on behalf of the plaintiffs say in effect that Mr. Swan's carbon rod or pencil is not only different from Mr. Edison's carbon filament mentioned in Claim 2, but it is totally and wholly different. The defendants' witnesses say, "In our opinion these two things are identically the same." Well, in these circumstances I must draw such conclusions on the point as my own uninstructed mind will enable me to arrive at. To my mind it does seem that a carbon pencil or rod is a very different thing from a carbon filament. It is difficult to express exactly the whole process of reasoning by which I come to that conclusion, but it seems to me to carry one a long way on the road to that conclusion, to say that a rod or pencil is a rod or pencil, and a thread is a thread. There are, however, certain differences which are not difficult to explain, it appears to me. It seems clear that one of those differences between Mr. Swan's conductor and Mr. Edison's conductor is this: Mr. Edison's conductor possesses smallness of cross-section, combined with other properties which Mr. Swan's does not. Mr. Edison's conductor possesses a degree of flexibility which, to my mind, is not even approached by Mr. Swan's, and I think I am again confirmed in this view by some of the evidence given by Dr. Odling. "Except in Swan's," he says, "I cannot point to anything in this specification in which only this rod or stick of carbon alone is described, even in the lamp of Swan produced. In the lamp that Swan produced the conductor is a rod." To show what he meant, he says, in effect: "True, it is a rod, but it is a filament also, and I refer to Mr. Swan's subsequent communication the 1st of January, 1882, in which he calls his conductor a filament." But then, as you know, as a matter of anticipation, that broke short in Dr. Odling's hands, because instead of its being in anticipation it is about 12 months after the event. He goes on to say, "As applied to a conductor exclusively of carbon, I cannot point out any anticipation of Edison's statement contained in the passage from line 23 to line 43 on page 3 of the specification." The statement to which he referred begins with the words, "heretofore lighting by incandescence," and ends with the words, "high temperature." Now, I cannot help thinking that if Mr. Swan at the time in question, not in January, 1880, but at an earlier period, before Edison's specification—had Mr. Swan known of the various advantages of Edison's carbon filament as used, his lamp would never have contained a straight rod fixed at each end. By straight of course I mean lying even between the two points of junction. That straight rod was fixed to the end of platinum wires. Moreover, I think there is no evidence to show that before Mr. Edison's specification he knew how to make a carbon conductor of anything like so small a cross section which would answer the other requirements stated. The first time I can find Mr. Swan's conductor spoken of by him as a filament is in his final specification of the patent which forms one of the subjects of this suit, and that is under date of the 1st of July, 1880, Mr. Edison's final specification being some seven or eight weeks prior to that date. What he really wanted was unknown to him; but, at all events, if he had chosen to take advantage of the knowledge conveyed to the public by Mr. Edison's specification, he could have done so; but you do find it is true that Mr. Swan some weeks later is found calling his carbon conductor a filament. A rose does not smell the sweeter for being called a rose, and the fact that Mr. Swan did subsequently call that rod a filament does not at all convince me that it was properly so called. I do not forget that it is also in evidence on the part of one or two witnesses, Dr. Odling among the number, that electricians have adopted the word filament, and, as I understood him, it is applied to all manner and kinds of carbon conductors in these incandescent lamps. Well, that may be so. Words often become when applied to particular trades or sciences twisted from their original meaning. "A dozen" at one time meant twelve, but I am not quite clear that it has not been held to be in particular trades something different. It certainly in many does not mean twelve or anything like twelve. An illustration was shown when there was a very beautiful flower—a tulip—produced, and that portion of it which holds and supports the anther was referred to as a filament. I was told that in botany that was universally recognised as a filament, whatever size it might be. It has acquired that name in botany, just as these conductors amongst electricians have since acquired the name filaments. But I suspect they have received that designation since flexibility was introduced and rigidity was tabooed. I have, therefore, come to the conclusion, firstly, that there is no sufficient reason for saying that this patent is invalid on any of the grounds suggested on the part of the defendants; amongst others, of course, that there is no ground for the assertion that it has been anticipated, or, in other words, that it is not new. In the next place, I hold in Claim No. 2 that there has been a clear infringement by the defendants in their lamp. That being so, the decree I must give is that those of the plaintiffs who possess the legal beneficial interests—who are assignees—of Mr. Edison's patent are entitled to the verdict. With regard to the other plaintiffs, the action must be withdrawn or dismissed.

Mr. ASTON intimated that the action had been dismissed. He then asked for costs to be allowed on the higher scale, and that the lamps of the defendants should be handed over to the plaintiffs or destroyed.

Mr. CHARLES applied for a suspension of the injunction; but

Sir RICHARD WEBSTER pointed out that where a final judgment has been given in favour of the plaintiffs the injunction followed as a matter of course, otherwise it would stultify the decision of the judge.

Oswald v. the Maxim-Weston Electric Light Company (Limited).

This case came on for hearing in the Lord Mayor's Court, Guildhall, before the Recorder (Sir T. Chambers, Q.C.) and a jury, on Monday. The plaintiff, Mr. E. H. Oswald, sued to recover the sum of £35. 6s. 6d., being commission at the rate of 25 per cent. on £141. 7s. 3d. paid to the defendants for the supply of electric lamps and light at Covent Garden Theatre. The defendants pleaded that they never were indebted, and also that they had satisfied the plaintiff's claim before action was brought. Mr. Pollock, counsel for the plaintiff, said that an agreement was entered into between the plaintiff and Mr. Hugh Watt, M.P., managing director of the defendant company, by which plaintiff was to have 25 per cent. on an order which was obtained by the plaintiff for the lighting of Covent Garden Theatre for eight weeks during the Promenade Concert season, 1884. The defendants contracted to supply twenty arc lamps, but it was afterwards discovered that these would not be sufficient, and seven more were put up. The Covent Garden people paid the amount of the contract for the twenty lamps, but declined to pay for the extra seven, and the defendants sued them for the amount, which was £141. 7s. 3d., and recovered judgment. The plaintiff had been paid 25 per cent. commission on the total amount received for the twenty lamps, and he now claimed 25 per cent. on the £141. 7s. 3d. which had been so recovered. Mr. Lewis Glyn, for the defendants, said he might say at once, to save time, that the defendants declined to pay because they contended that they could not go on paying commission after the first order. The defendants contended that the supply of the extra lamps was in law nothing at all to do with the first lamps under the contract. The defendants might as well be expected to go on paying commission for a hundred years, or for any length of time if any work was done after the first order. The plaintiff had had 25 per cent. on the price paid for the first twenty lamps, and he (the learned counsel) thought that was quite enough. Mr. Pollock pointed out that the agreement between the plaintiff and the defendant was for commission on "lighting" the Covent Garden Theatre. The learned judge said he would not stop the case at present. The plaintiff, in his evidence, spoke to other transactions which he had had with Mr. Watt, who arranged to pay him 10 per cent. commission on all orders which he introduced from the country. When he spoke about procuring the order for supplying Covent Garden Theatre, plaintiff said he could not accept 10 per cent. commission. He must have 25 per cent. This was agreed to, and the agreement was put into writing. In any case he was entitled to 10 per cent. in consequence of the arrangement which had been come to with respect to all business introduced by the plaintiff to the defendant. For the defence, Mr. Hugh Watt, M.P., was called, and said he never had any transaction with the plaintiff previous to the one which was the subject of the present action. The plaintiff had asked to be appointed agent of the company at Nottingham. Witness went down there and made inquiries, but he did not appoint the plaintiff to the agency. Witness had never promised or agreed to pay the plaintiff 10 per cent. on any orders introduced. When the arrangement

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was made in writing to pay the plaintiff 25 per cent. the plaintiff verbally undertook to return a third of the commission. By some mistake the plaintiff had been paid £8 too much. The learned judge, in directing the jury, said that upon the terms of the agreement the plaintiff could not recover 25 per cent. upon the extra work. It would, however, be a question for the jury whether there had been a previous verbal arrangement to pay the plaintiff 10 per cent. upon all work introduced. The jury found for the plaintiff for 10 per cent, the exact amount to be ascertained by the registrar of the court.

**** *Owing to the length of our "Legal Intelligence," we are compelled to leave over to our next issue the interesting report to the Balloon Society by Mr. Alfred Thompson on "Electricity as a Safeguard against Fire," &c.*

COMPANIES' MEETINGS & REPORTS.

Oriental Telephone Company.

An extraordinary general meeting of the members of this Company was held on the 13th inst. at the offices, 14, Austin Friars, under the presidency of Mr. W. Addison.

The CHAIRMAN proposed a resolution confirming as special resolutions the resolutions passed at the extraordinary meeting held on the 20th ult. They were for making certain alterations and additions in clauses 56, 60, 61, and 64 of the Articles of Association of the Company, the object sought, as stated by the solicitor at the last meeting, being to withdraw from the Directors certain powers which it was thought were too wide for them to exercise without the shareholders' consent.

Mr. T. LLOYD seconded the motion, which was adopted.

West India and Panama Telegraph Company (Limited).

Report of the Directors, to be presented at the eighteenth ordinary general meeting of members, to be held at the City Terminus Hotel, Cannon-street, on Thursday, the 27th inst., at 12 o'clock.

The Directors submit the accounts for the six months ending 31st December, 1885. The amount to credit of revenue is £38,008. 18s. 7d., and the expenses have been £23,191. 2s. 1d., leaving a balance of £14,817. 16s. 6d., which, with the balance of £1,920. 5s. 9d., brought from last account, makes a total of £16,738. 2s. 3d. Of this sum the Directors have placed £2,000 to reserve, leaving an available balance of £14,738. 2s. 3d., with which it is proposed to deal as follows :—

Payment of 6s. per share on account of arrears of dividend on the First Preference Shares.....	£10,368	18	0
Balance to current half-year's account.....	4,369	4	3
	£14,738	2	3

The traffic receipts for the half year show a decrease of £2,176. 8s. 11d. on those of the corresponding period of 1884. This decrease can only be attributed to the commercial depression which is affecting the West Indies, perhaps, even more severely than other parts of the world. The Company's ss. "Grappler," referred to in the last report as being on her way home, after a thorough overhaul in the Thames, returned to the West Indies with 250 knots of cable on board, and the Directors have great satisfaction in adding that she has since repaired the original Cuba-Jamaica section with an expenditure of 71 knots, thus duplicating a most important section of the Company's system. The duplicate Jamaica-Porto Rico cable, which, it will be remembered, was restored on the 24th October, 1884, again became interrupted on the 28th November last. The "Grappler," when on her way to repair the Cuba-Jamaica section was ordered to examine the locality of this interruption. The break was found to be in about 2,400 fathoms of water, and the repair will require the expenditure of a considerable length of new cable, as no workable depth was found along the course of this line in the vicinity of the interruption. The cable must therefore be recovered at the nearest practicable points on each side of the break, and a new length laid in between those points. As far as soundings hitherto obtained enable an opinion to be formed, some 160 knots of cable will be required to complete the connection. The Trinidad-Demerara section has been again interrupted, and as, notwithstanding costly repairs, it has not worked satisfactorily for some years, proposals have been made to the colony of British Guiana for laying a new cable. The length that may be required for this renewal will be over 300 knots. If the Company's proposals are accepted, the cost of this new cable as well as that of the Cuba-Jamaica and Jamaica-Porto Rico repairs already referred to, will cause heavy draughts on the reserve fund. Several breaks in the cables occurred during the half-year under report and have been repaired. All stations are now in telegraphic communication. The shareholders were doubtless as much surprised as were the Directors by the appearance in November last of an advertisement under the authority of the Postmaster-General announcing that Her Majesty's Government were prepared to recommend Parliament to grant a subsidy for the construction and working of a submarine cable from Halifax (Nova Scotia) to Jamaica, *vid* Bermuda, and calling for tenders for the same. The proposed line is part of a scheme that was before the Government in 1882, when, being adversely reported upon by the late Mr. Fawcett, the Postmaster-General at the time, it was rejected. Among the grounds of Mr. Fawcett's objections were the physical difficulties of the route between Bermuda and the West Indies, which passes over the greatest known depths in the world, and the evident injustice to the West India and Panama Telegraph Company which a State-subsidised competition would involve. Mr. Fawcett's objections were apparently so fatal to the scheme, and so novel is the project of using the national resources to compete with a system the establishment of which had received the cordial encouragement of the colonies and the approval of the Home Government, that the Directors little expected to hear of it again, and they thought themselves justified in this belief by the facts that Jamaica is already connected with the nearest telegraph system by three of this Company's cables, that it has been in telegraphic communication with England for the last 15 years, and that the volume of the whole West Indian telegraphic business is not sufficient to employ a single line of cable for more than about five hours a day. In these circumstances they could not imagine that Her Majesty's Treasury, which had invariably refused every application from this Company for assistance in its efforts to continue the unremunerative telegraph service of the West Indian Colonies, would sanction the payment of a subsidy for an unnecessary fourth cable, whose competition for the poor traffic of the region would seriously impair the power of this Company to maintain the West Indian system. The views of the Directors on the proposal were communicated to the proper authorities. It is now six months since the appearance of the advertisement, and nothing has since been heard of the scheme. It is hoped, therefore, that it will be allowed to drop, and that this Company will not have—to use Mr. Fawcett's words—"just cause for complaint against Her Majesty's Government if it were now to subsidise a rival company." In accordance with the Articles of Association, Henry Holmes, Esq., and Henry Weaver, Esq., retire at this meeting and offer themselves for re-election. John George Griffiths, Esq., the auditor, also retires and offers himself for re-election.

BUSINESS NOTICE.—We understand that Messrs. Ganz and Co., of Buda Pesth, manufacturers of Déry, Blathy, and Zipernowsky's secondary transformers, have opened an office in No. 4, Westminster-chambers, Westminster, with the view of undertaking electric light installations in this country.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. MAY 19.		BUSINESS DONE WEEK ENDING MAY 19. Highest.	Lowest.
Anglo-American	31,	32	31¼	30⅞
Do. Preferred	52,	53	53	51½
Do. Deferred	10,	10¼	10¼	10 1-16
Brazilian Submarine	10¾,	11	11⅛	10⅝
Cuba	10½,	10⅝	10⅝	10⅝
Do. Preference	18,	19	18½	18⅛
Direct Spanish	1½,	2	1⅝	—
Do. Preference	9,	10	—	—
Direct United States Cable	8¾,	9	9	8¾
Eastern Telegraph	10⅝,	11⅛	11	10⅝
Do. 6 per Cent. Preference	14⅜,	14⅝	14½	—
Do. 5 per Cent. Debentures, 1899	105,	108	—	—
Eastern Extension	12⅛,	12⅜	12⅜	11⅛
German Union	9½,	9⅞	9⅝	9½
Globe Telegraph and Trust	6½,	6¾	6¾	6 9-16
Do. Preference	13½,	13½	13½	13½
Great Northern	12½,	13	13⅛	12⅝
Indo-European	34,	35	35	34
Reuter's	6,	6½	—	—
Submarine	200,	210	—	—
West India and Panama	⅝,	¾	11-16	—
Do. 1st Preference	8½,	9	9	8½
Western Brazilian	7,	7½	7½	7
Western Union 7 per Cent. 1st Mortgage	118,	122	—	—
Do. 6 per Cent. Sterling Bonds	103,	107	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	13-16	15-16	—	—
Oriental	3-16	5-16	—	—
United Telephone	13,	13½	13½	13

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	2⅜,	2⅝	2⅛	2⅛
Do. (fully paid)	4½,	5	4½	—
Swan	1½,	1½	1⅝	1 5-16
Maxim-Weston	3-16	5-16	—	—

MISCELLANEOUS.

Telegraph Construction	37	38	38	37
India Rubber, Gutta Percha, and Telegraph Works	23	24	23½	22½

TRAFFIC RECEIPTS FOR APRIL, 1886

COMPANIES.	April, 1886.	April, 1885.	Increase.	Decrease.
Cuba Submarine	3,300	3,883	—	583
Direct Spanish Telegraph	1,597	1,510	87	—
Eastern Extension	34,292	41,233	—	6,941
Eastern Telegraph	47,611	63,085	—	15,474
Great Northern	19,800	—	—	—
West Coast of America	3,225	—	—	—

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NOTES.

THE STEAMSHIP "AGNES."—We understand that this vessel, belonging to the Eastern Extension Company, arrived home on Friday last, and is now in the South-West India Dock.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 21st inst. were £2,368, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

THE TELEGRAPH IN CHINA.—The Chinese Government have, it is said, in contemplation to extend telegraphic communication from Wuchang, on the Yangtze river, to the city of Yunnan, in the Yunnan Province. The line is expected to be open by the end of the present year.

RAILWAY CONTRACTS.—Messrs. Blakey, Emmott, and Company have again secured nearly the whole of the London and North Western Railway Company's contract for electrical apparatus and cotton-covered wire. They have also obtained a portion of the Manchester, Sheffield, and Lincolnshire, and Lancashire and Yorkshire Railways' contracts.

LIGHTHOUSE AT ROUND ISLAND.—The foundation stone of this lighthouse, to the north of the Scilly group, has been laid by Lady Douglass, wife of Sir James Douglass, chief engineer of Trinity House, London. The building of this structure will be under the superintendence of Mr. W. T. Douglass, resident engineer of the works now being executed at the Bishop Lighthouse.

RESISTANCE OF COPPER.—Some experiments, carried out by Sigmund von Wroblewski, upon the resistance of copper at very low temperatures, show that there is no permanent alteration in the resistance due to extreme cold, and that the electrical resistance diminishes at a greater rate than the temperature, leading to the conclusion that resistance vanishes before absolute zero can be reached.

FRENCH AND ENGLISH TELEGRAPHS.—The President of the Chamber of Commerce has made an application to M. Granet, Minister of Posts and Telegraphs, to establish direct telegraphic communication between Havre and Liverpool. M. Granet replied that the telegraph system between England and France was regulated by treaties between the two countries, but these treaties might be modified on their expiration.

ELECTRICITY AND WHISKY.—According to the *Albany Sunday Press*, the ripening of spirits by electricity is now effected on the other side of the Atlantic. Three incandescent lamps of 32 candle-power are inserted in a barrel of whisky, and their light and heat are said to produce the same effect on the spirit as the ripening of age, thus fitting the whisky for market in a very short time. Good judges report that the process improves the quality of the spirit.

ELECTRIC TRAMWAY.—The success which has attended the working of the electric tramway at Blackpool, which has been fully described in previous numbers of *The Electrician*, is an unequivocal answer to those who doubted the practicability of applying electricity to this means of locomotion. That the tramway in question in three consecutive days recently carried 15,000 passengers over a line two miles long without any hitch or delay is an eloquent testimony to the rapid development of electrical science and its future possibilities in the direction of practical mechanics.

ROYAL SOCIETY.—At the recent *soirée* of the Royal Society, among other electrical apparatus Messrs. de la Rue and Hugo Müller showed how the chloride of silver battery could be applied to electric lighting by a quantity arrangement. Instead of using a solution of chloride of ammonium simply, the solution, containing 2½ per cent. salt, is converted into a vegetable jelly, by dissolving in it Ceylon moss (Agar-Agar) to make a stiff jelly; this supports the zinc. The chloride of silver in powder is spread evenly on the bottom of the dish on which a piece of silver foil is placed.

ELECTRIC COMMUNICATION WITH LIGHTSHIPS.—An influential meeting was recently held at Ramsgate to promote electric communication between lightships and the mainland. Colonel King-Harman, M.P., was among the speakers, and promised to do all in his power to get the Government to take active steps in the matter. The following resolution was passed:—"That this meeting, being of opinion that it is desirable to promote the movement for establishing electric communication between lightships and shore, a deputation wait on the Board of Trade to impress on them the importance of the subject."

AN ELECTRICAL "STOP."—A German *savant* who had long been suffering from the everlasting pianoforte playing next door has devised the following method of putting a stop to it at pleasure:—An electric battery was connected with a powerful electro-magnet. Whenever a stream of electricity was turned on its effect could easily be felt through the wall by the horizontal steel strings in the piano, which is instantly put out of tune. Whenever the electric stream was stopped, which occurred as often as the victim of the piano plague went out, the mystical influence stopped, and Miss Else, the offending pianist, could play.

ELECTRICITY IN MILAN.—The electric light is very popular in Milan. The electric light company doing business there is constantly receiving fresh orders for installations to be put up in various parts of the city. The company had in operation on the 1st of January, 1885, 5,300 incandescent lamps, and exactly a year later the number had increased to 7,177, in addition to 66 arc lights, while by the end of March last these numbers had been increased by 846 incandescent and 13 arc lamps. Since then further additions have been made, and the company expect to present a handsome balance-sheet at the end of the year.

THE GERMAN ZINC INDUSTRY.—All zinc works are at present busily engaged on consignments for foreign customers. By reason of the long winter and the interruption to navigation, the stocks on foreign account have accumulated both in Westphalia and Upper Silesia, but the deferred orders are now being rapidly discharged. As compared with last year, however, both in Rhineland-Westphalia and Silesia, the stocks have considerably fallen off, April 1st showing a decrease of 4,300 tons. It is said that tin has been found in Dakota, in North America. How this will affect the zinc industry remains to be seen.

DRIVING COUNTER-SHAFTING BY DUPLICATE ENGINES.—The usual method of driving counter-shafting by duplicate engines has made it necessary to employ fast and loose pulleys or clutch gearing on the shafting and a wide fly-wheel on the engines. There has also been much difficulty with these arrangements in getting the second engine to the speed of the engine it is desired to relieve, and in shifting the straps, but we now learn that a new method has been devised by Mr. W. W. Beaumont, M.I.C.E., of driving in such a manner that only one pulley opposite each engine is necessary, and it is only necessary to start one engine to liberate the other.

THE TELEPHONE IN THE MALAY ARCHIPELAGO.—Complete systems of telephone lines have recently been completed at Lingha and Rhion for the Sultans of these islands At Lingha

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seven miles of line have been erected and five stations, all of which are in connection with each other. At Rhion there are four stations. Lingha is an island 150 miles from Singapore, and Rhion about 50 miles from the same place, both in the Malay Archipelago. Gower-Bell telephones have been used. These are the first lines (either telephonic or telegraphic) erected in these islands, and they are reported to work admirably. The work has been ably done by Mr. J. B. Saunders, of the Oriental Telephone Company's staff.

THE ELECTRIC LIGHT IN SPAIN.—In continuation of our former remarks upon the proposed installation of the electric light in Madrid for public use by merchants and others who have quarrelled with the gas company, and who are in the meanwhile using oil, we learn from the Spanish paper *El Dia*, of Monday last, May 24th, just to hand, that Messrs. Edison's agent, who recently arrived in Madrid, has left by express train for Paris, in order to lay before the representatives of the Edison Company in Paris the plans of the proposed installation. Madrid advices also state that experiments were to be made this week in the Mercantile Club of two systems of electric lighting, one by a Paris house and the other by a Marseilles firm.

DIAMAGNETISM OF QUARTZ CRYSTAL.—Hitherto no substance among those that exhibit diamagnetic properties has been observed to possess any permanent diamagnetic polarity analogous to the permanent paramagnetic polarity of hard steel. The property of retention of diamagnetisation is, however, found by Dr. O. Tumlirz, of Prague, to be possessed by rock crystal. Both those specimens that show right-handed and left-handed optical properties are alike in this respect, and the axis of diamagnetisation appears to be independent of the crystallographic axis, and dependent only on the axis of initial magnetisation. Dr. Tumlirz, whose investigation is published in *Wiedemann's Annalen*, appears to think that these facts negative Becquerel's theory of diamagnetism.

RUNNING A STAMP MILL BY ELECTRICITY.—It is reported from New Zealand that a Dunedin electrical engineering firm is carrying out a contract for the transmission of power to run a stamping battery of twenty heads. The scene of operations is a gold mine in the mountainous country some thirty miles beyond Lake Waktipu, and the power to run the battery is transmitted from a waterfall in the neighbouring valley, straight over a mountain of about 2,000ft. in height, and for a distance of about two miles. The conducting wire is of the same size as an ordinary telegraph wire, but of copper, and is suspended from telegraph insulators in the usual manner. No doubt there are many places in this country where power could be provided most economically from water-powers and dynamo machines, as in the above case. We shall be pleased to hear from any mills so situated.

E.M.F. OF VOLTAIC ARC.—Von Lang's direct measurement of the E.M.F. of the voltaic arc is thus described in the *Journal de Physique*:—Two arc lamps are placed symmetrically in the circuit of a strong Bunsen battery. The middle A of the battery and the middle B of the conductor which unite the two lamps are at the same potential. The resistances of the two portions of the circuit which go from A to B are evaluated by means of a Wheatstone bridge; first, when the two lamps are in operation; second, when the carbons have been replaced by resistances which bring down the current to its former value. Half the difference of the two numbers obtained gives the resistance, which is balanced by the negative E.M.F. of one of the voltaic arcs. This E.M.F. is calculated by multiplying the difference obtained by the intensity of current. Thus the author obtains the value 38·6 volts.

"THE TIMES" AND THE PHONOPORE.—Mr. C. Langdon Davies, who is the inventor of something which he calls a phonopore, cannot be congratulated on having enlisted *The Times* as an exponent of his invention. Whenever the leading newspaper takes a scientific matter in hand the result is almost invariably disastrous either to its client or the investing public. We know nothing about the phonopore; but we do know that the account of it which appeared in yesterday's *Times* is absurdly unscientific. If Mr. Davies has discovered anything that will pass muster under competent inspection he should go to a scientific or technical journal. And on the other hand, we consider that *The Times* has no business to publish matter of this kind, which may delude the speculating world, without first assuring itself of the sanction and countenance of judges more impartial than any inventor is ever likely to be.

ELECTROLYSIS OF SOME CHEMICAL COMPOUNDS.—M. D. Tommasi, according to an abstract in the *Journal* of the Chemical Society, maintains that if an aqueous solution of potassium chlorate acidified with sulphuric acid so diluted that when treated with metallic zinc no reduction of the chlorate takes place is submitted to electrolysis, the anode being formed of pure zinc, reduction occurs and potassium chloride is formed, although if the electrolysis is conducted with platinum electrodes no such action takes place. The reduction is therefore due to the direct union of the zinc with the oxygen of the chlorate, and not to the action of nascent hydrogen. Potassium perchlorate is not reduced by electrolysis, even when a zinc electrode is employed. A dilute aqueous solution of chloral hydrate in a porous cell placed in a vessel of water acidified with sulphuric acid was electrolysed, the cathode being placed in the chloral and the anode in the water; chlorine and free hydrogen were given off at the cathode, and aldehyde was formed.

THE BROADWAY ARCADE RAILWAY.—A Street Railway Bill which has just passed the New York State Legislature and has received the approval of the Governor introduces a feature into street railway construction that may be fraught with excellent results. The Bill is known as the Broadway Arcade Railway Bill, and, as its name implies, it provides for the construction of an electrical railway the entire length of Broadway, New York. It is also to be an underground railway, but not in the sense of the London underground railway. In short, instead of being, as our Metropolitan is, a tunnel, it will be an arcade—Broadway will practically be scooped out to a sufficient depth to allow of another street below the present one, with two lines of shops, footways, and railway lines. But these features do not exhaust all the conveniences that will be effected by the proposed construction. The space underneath the footway on either side of the arcade will be utilised for the water and gas mains, and for the telegraph and telephone wires; and hence the necessity of breaking up the road or pathway whenever it is necessary to do anything with gas or water pipes, or with telegraph wires, will be obviated.

PREPARATION OF METALS FOR NICKELISING.—Surfaces to be nickelised are usually polished before being submitted to the action of the bath. After this operation is finished they remain covered with a slight greasiness, which is often still further increased by contact with the hands. This is one of the principal causes of failure to obtain a perfect nickelisation, and it is therefore essential to have the surfaces as clean as possible. The *Elektrotechnische Rundschau* says that the following process will always yield good results:—Prepare a hot solution of one part by weight of potash in ten of water, and place the object in this and allow it

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to remain therein for one or two minutes, and then wash with plenty of water. Next put it into a bath made by slacking quicklime in water and adding enough water to make the mixture look like milk. Then wash again with fresh water. Finally, place the object in a solution of one drachm of hydrochloric acid to a quart of water, and wash a third time with pure water. The surfaces will now be well adapted for receiving a nickel coating, and the only precaution to take is to prevent them from coming into contact with the hands or other greasy bodies.

TELEGRAPH WIRES AT BELFAST. — The Belfast Main Drainage Bill, as amended in the House of Commons, contains the following in relation to telegraph wires:—"Fixing, placing, or attaching wires, tubes, or other apparatus across, over, or along, but not under, any public street for telegraphic, telephonic, or any electrical purpose. Section 55 provides that no such apparatus shall be fixed, placed, or attached as to cross over or pass along any public street except with the previous license, in writing, of the Corporation, under the hand of the Town Clerk, which license shall not be unreasonably refused, and subject to such terms and conditions as they may from time to time prescribe, so as to prevent danger, annoyance, or obstruction to passengers or traffic passing over or along, or being in or upon, such street. Any person offending against this enactment, or who fails to observe and perform any of such terms and conditions, shall be liable for each offence to a penalty not exceeding £10, and to a daily penalty not exceeding 40s. for every day the offence shall continue after notice, in writing, under the hand of the Town Clerk, of the breach of the enactment, and the Corporation may cause such apparatus to be removed and altered, and may recover the expense of and incidental thereto in any court of competent jurisdiction."

AURORA BOREALIS.—A note of the Abbé Maze to the *Academie des Sciences* says that an Aurora Borealis was observed by him at Rolleville (Seine Inferieure) on the 30th March, thus coinciding with the magnetic disturbance reported by M. Mascart. He says that about nine o'clock in the evening of Tuesday, the 30th March, at Rolleville (latitude 49° 54′ 52″; longitude 2° 7′ 27″ west), he perceived a great brightness in the north direction. It was a white and vibrating light. This last character made him think it was an Aurora. Nevertheless he could not recognise any of the characters which he had observed at other times. There was no colouration, except towards the zenith a slightly reddish tint, something like the greyish red which one observes between the two red bands of the double rainbow. He did not observe either any of those jets which sometimes dart in the sky. A great black stratiform cloud which was on the horizon prevented him from determining with precision the exact place of the centre of action of the Aurora; but, as far as he could tell, it was in the magnetic meridian. He was a good judge on this point, since he had spent the day in determining the meridian of the place. At ten o'clock the phenomenon still continued; at eleven the sky had become so covered with clouds that no observation was possible. The next evening the north horizon appeared rather brighter than it should be, but there seemed none of the special characters of an Aurora.

THE INSTITUTE OF CIVIL ENGINEERS.—The annual general meeting of the Institute was held on Tuesday, May 25, Sir Frederick Bramwell, F.R.S., occupying the chair. As fifty years had elapsed since a connected account had been given of the origin and progress of the Institution, it was thought not inopportune to submit a condensed narrative of the successive steps by which its present position had been arrived at. This historical notice stated that the Royal Charter of Incorporation was granted in 1828, and went on to describe the qualifications of members and associates, and the modifications which had taken place at various times since. It was also shown that various modifications had been made in the composition of the governing body, and that in 1844 an alteration was made which had materially influenced the future of the Institute. This was the change in the duration of the Presidentship, which had up to that time been practically a permanent appointment. Up to 1880 the president seems to have been elected for a period of two years, or rather elected for one year, and reappointed the second. Since 1880 there has been an understanding that the president should hold office for one year only. The present secretary has held office for thirty years, and if we may interpolate an opinion, we should say that it is due to his labours that the Institute is at the present moment so flourishing, and especially that the publications of the Institute are so valuable. In 1836 there were on the register 146 members, 100 associates (many of whom were afterwards transferred to the class of members) and 14 honorary members—together 254.

TAUNTON.—On May 1st the Thomson-Houston system of electric lighting was successfully inaugurated in Taunton. This is the first provincial town in England that has adopted the system, although it has been largely used in the States. The initiative in this work has been taken by Mr. Massingham, who, after careful investigation of the various systems in use at the Kensington Exhibition last year, selected the Thomson-Houston system for trial, and attempted to float a local company for Taunton. In this he failed, but, undismayed, determined himself to undertake the work, and arranged with Messrs. Laing, Wharton, and Down, the representatives for the system in England, to install a thirty-light machine with the necessary lamps. The power is obtained from a horizontal steam engine with locomotive boiler by Messrs. Easton and Waldegrave. The engine is fitted with a Pickering governor. The light has been pretty extensively adopted by the principal tradesmen of the town, and we are given to understand that so much is the light appreciated that a further extension of the plant will very soon be rendered necessary. In one or two cases Edison-Swan lamps are used for the lighting of interiors instead of arc lamps. A grant from the Town Council and the Taunton Market Trustees, supplemented by private subscription, found the necessary funds for the erection of the masts and circuit for the lighting of the parade, where there are seven arc lights; but the cost of the maintenance of these lights is defrayed by Mr. Massingham till the end of the year, when it is hoped the authorities will, seeing the manner in which the light is appreciated, take the cost of maintenance off his hands upon themselves. Messrs. Laing, Wharton and Down and Mr. Massingham are to be congratulated upon the success of their enterprise.

SUBMARINE TELEGRAPH CLERKS' LIBRARY.—On the evening of Friday (says the *City Press*) the annual general meeting of the subscribers to the Submarine Telegraph Clerks' Library was held at the Talbot, London-wall, Mr. T. Sharkey (chairman of the committee) presiding. The balance-sheet, though dealing with no large amount, was perfectly satisfactory, showing, as it did, a small sum on the right side. The library was established in 1877 for the use of the clerks in the transmission department of the above company, and has steadily progressed until it now consists of some 1,200 volumes pretty equally divided into light and thoughtful literature. A great deal of the credit for so much success is due to the hardworking and courteous honorary secretary, Mr. T. P. Mullane, and advantage was taken of the meeting to testify the appreciation of the members of those

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qualities by presenting him with a gold watch suitably inscribed, and an illuminated address. The presentation was made by the chairman, who, in a few graceful words, expressed the esteem and honour in which Mr. Mullane was held by those who knew him. Not only as honorary secretary had Mr. Mullane served the subscribers, but to him was due the first inception of a library, and to him they owed many a pleasant hour by their "ain firside." The honorary secretary found it very difficult to reply. As a rule, when testimonials are about one of the first to know of it is the recipient; but in this case the committee had worked so efficiently and so quietly, and had met with such ready sympathy that nothing of their intention had leaked out. Mr. Mullane managed to utter a few words of thanks, comparing his astonishment to the result of a thunder-bolt from a clear sky. His thanks were cut short, however, by a rousing "He's a jolly good fellow," and the meeting resolved itself into a musical party, presided over by Mr. Killick.

Folkestone Exhibition.—The electric lighting of the Exhibition has been entrusted to the Electrical Power Storage Company, and is one of the most interesting features of the Exhibition. The whole installation has been designed by the engineers of the company as a perfect model of a large electric lighting station, such as would be required for the lighting of a town, and both arc and incandescent systems are represented. The arrangements made enable the different groups of arc lamps to be turned on and off at will without the remaining lamps being in any way affected, and by means of the E.P.S. accumulators a total extinction of the incandescent lamps is rendered practically impossible. As a further safeguard, the whole plant has been sub-divided, and each of the galleries and other departments is supplied from two separate and distinct circuits. Two sets of batteries in glass boxes and of the newest type, containing thirty-one plates in each box, will be charged in the day time, and kept as a reserve. There are in all thirty-six arc lamps, each giving a light of 3,000 candles, and 1,250 incandescents, of ten candle-power. The arc lamps are fixed outside for the lighting of the gardens and entrance to the Exhibition, and are also suspended from the roof in the central nave, which will be very brilliantly illuminated at night. The power is supplied from two Marshall engines, each giving eighty horse-power, this being transmitted by means of countershafts to four Crompton dynamos, which supply all the current for both arc and incandescent lamps. There has, up to the present, been no public exhibition for lighting which has been so carefully worked out in all its details, and electricians will doubtless find much of the apparatus well worthy of their inspection. The whole of the electric light machinery and appliances for the generation of the current are contained in a building separate from the galleries of the Exhibition, being connected only by a covered way for the convenience of visitors who may desire to inspect them. This also applies to the refreshment rooms of Messrs. Spiers and Pond, for whom a similar covered way has been provided.

Edinburgh Exhibition.—An exhibit in Court 21 shows a regimental field telegraph, designed for the Queen's Edinburgh Rifle Volunteer Brigade by Colonel the Right Hon. J. H. A. Macdonald, C.B., M.P., Commandant. It is highly desirable that every regiment should carry its own telegraph appliances, so that it may establish telegraphic communication with its own outposts when acting alone, and that when acting with others telegraphic communication may be more rapidly established by each regiment laying its own cable on reaching camping ground instead of the whole telegraphic plant for a division being carried in separate waggons and worked by a separate department. This field telegraph is designed to enable the necessary plant for telegraphing to be carried regimentally. It consists of—1. One mile of double conductor insulated cable. The main wire is in the centre, and covered with insulating material. The "return" consists of five small wires wound round the covering of the inner wire, and this is again covered. The "return" thus makes the obtaining of an "earth" unnecessary, and also acts as a protection to the main wire. The cable is wound in two lengths on two bobbins. 2. Telephone transmitters and receivers for ordinary speech, or where articulate sounds cannot be heard, a special arrangement by which the Morse alphabet can be read by telephone. (This latter instrument is designed by Samuel Vyle, Esq., late of the telegraph department, G.P.O.) 3. A special coupling for rapidity, and which avoids the use of all screws which might get lost, or sockets which might get clogged in the rough usage of a field telegraph. 4. Poles to carry the cable across roads where traffic might injure it. The guying arrangements of these poles make them adaptable to any position and enable the erecting, taking down, and re-packing to be effected with great speed. 5. Two bicycles to carry the plant. The poles are carried over the handles of the bicycles, and each bicycle has a half-mile bobbin supported on its backbone. The bicycles are trundled by the telegraph troop, the draught being extremely light. If surprised, the poles, which are of comparatively trifling value, can at once be thrown off and the bicycles mounted for escape.

Secrecy of Telegrams.—In the House of Commons on Monday Dr. Cameron asked the Secretary to the Treasury whether the attention of the Postmaster-General had been called to the following statements made by witnesses examined by Sheriff Ivory and published by that gentleman in a pamphlet entitled "A Report by the Sheriff of Inverness, Nairn, and Elgin to the Commissioners of Supply of Inverness-shire":—"Deputy Chief Constable Aitchison.—When he (Captain Mahon) came he sent for the inspector and myself, and we met him then and on several occasions afterwards. On these occasions he showed us various telegrams, for some of which he applied to Sheriff Spens for authority to show us, but he had also shown several to us before he got such authority. . . . A day or two afterwards he came to us with a bundle of telegrams. . . . I think he showed us these telegrams on this second occasion. Captain Mahon showed us (Inspector Macdonald Gillander and me) another telegram on a third occasion. . . . I asked Captain Mahon to allow me to get a copy of these telegrams. He wired for leave to the secretary at Edinburgh, and he showed me the reply telling him not to show the telegrams to any one. I then told him he must show them privately to the Chief Constable at Inverness and to the Sheriff in Edinburgh, and he said he would do so." "Deputy Procurator Fiscal Gillander: Captain Mahon showed me a telegram. He showed me a batch of twenty or thirty telegrams, all or most in different handwriting, one from the postmaster, Portree, and the others from the crofters and their friends;" whether Captain Mahon was "a person having official duties connected with the Post Office," and, if so, whether he was forbidden by the Electric Telegraph Act, 1868, sec. 20, to disclose or in any way make known the contents of telegrams except under certain conditions prescribed in the the Act; whether in any, and if so in how many, of the instances quoted Captain Mahon had obtained the authority prescribed by law for the production of the telegrams; and whether their production was made without legal authority, what steps the Postmaster-General proposed to

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take for the vindication of the provisions made by law for the secrecy of telegrams and the punishment of Post Office officials who disclosed their contents, or those who induced such officials to make such disclosure.—Mr. H. Fowler: In producing these telegrams, without the necessary legal authority for so doing, Mr. Mahon, who is an assistant surveyor of the Post Office, acted under a mistaken sense of his duty. He believed that in showing the telegrams to the police he was not only not contravening the law, but furthering the ends of justice. Mr. Mahon has been informed that he was in no way authorised to disclose the telegrams in question; but the Postmaster-General is advised that in the circumstances it would not be proper to institute proceedings against him under the Telegraph Acts.—Dr. Cameron said that on the Civil Service Vote for the telegraphs he would call attention to the matter.

HALF A CENTURY.—Fifty years ago is a period well within the remembrance of many of us. Fifty years ago the Queen ascended the throne, and the period is one which permits of comparison. In 1836 Prof. Louyet suggested the use of incandescent lamps for mining purposes. He said:—"It seems to us that here is the place to express our astonishment at seeing that one of the most beautiful discoveries of modern science has not been rendered available for the illumination of the galleries (in mines). We would speak of the incandescence of charcoal produced in vacuum by means of the voltaic pile. . . . There would not be the least fear of danger, since the focus of light would be completely insulated from the external air." The suggestion of 1836 is a reality in 1886, and more than one mine is illuminated by incandescent charcoal in a vacuum, actuated not by the voltaic pile but by the dynamo. In 1836 appears in what may be termed *the* scientific book of the year the following description of plating: "The old method of plating was to apply thin silver leaves over brass articles after they were in other respects completely finished, and is still known by the term French plating; and some English manufactured goods, particularly those on steel, are plated in this manner; such, for example, as plated dessert knives, and other articles for the table. Thus, for instance, the knife being first properly formed in steel, a piece of silver leaf is cut to cover the knife on each side; it is then placed for a short time at the entrance of the plating furnace, during which the union of the silver and steel is completely effected, and it only remains to give to it its proper burnish. With brass goods the polishing is first produced on the original article. They are then rendered free from grease and every other extraneous matter, and the part to be plated is heated to a temperature just below that which causes a change of colour in the metal. Leaf silver is then laid upon the part, and while hot is rubbed with a steel burnisher perfectly dry and clean. By this means the silver was made to adhere to the brass, which, from the action of the burnisher, assumed a fine polish. The goods thus plated differ but little in appearance from those plated according to the present method; but they possess less permanency, and this old practice is almost entirely laid aside by English platers, except in the cases above referred to. According to the present practice, the metal is first produced in sheets plated on one or both sides, and the goods are manufactured at once in the plated form. The first process consists in casting an ingot of alloy of copper and brass, generally about one and one-eighth of an inch in thickness, three inches broad, and eighteen inches long. Great precaution is required in this process to obtain a very perfect ingot, for any holes or other imperfections will produce a general defect in the plate after rolling. The ingot is cast in cast-iron moulds, having rising mouth-pieces to give a certain pressure to the metal, and to allow any impurities to rise above the general surface, and considerable skill is required to have the heat of the mould and that of the metal properly adjusted." In 1886 electro-metallurgy is a larger industry than electric lighting.

ON MAGNETISATION.—A note of M. Mascart to the *Academie des Sciences* says, when a feebly magnetic and isotropic body is placed in a uniform field, it takes a magnetisation parallel to the field, and its coefficient of magnetisation k is the ratio of the magnetic moment for unit volume or intensity of magnetisation to intensity of field. On the contrary, with very magnetic substances such as iron, nickel, and cobalt, one must take into account the reaction produced by the induced magnetism, and the preceding definition is no longer applicable except for cylinders of indefinite length magnetised longitudinally or for closed rings. The calculation of the magnetising force as a function of the external field is very simple in the case of the sphere, the ellipsoid, or an indefinite cylinder magnetised transversely; but, except in the case of very long ellipsoids, the coefficient of magnetisation may vary between very extended limits without the magnetic moment of the body being sensibly modified. The smallest defects of homogeneity have then a considerable influence. The coefficient of magnetisation has often been determined by the use of cylinders placed parallel to the field, and which are likened to indefinite cylinders or to ellipsoids of the same length and middle section; then either the magnetic moment of the body is measured or the quantity of the induced current in a coil which surrounds the mean section when the magnetism is reversed. With rings the method of induced charges only can be employed, and much higher coefficieients of magnetisation are generally found. Hence it may be asked if one of the methods is at fault, and if, for example, there is produced in closed rings a peculiar phenomenon which exaggerates the effects of induction. To solve this question I have employed for the same metal both closed rings and a series of cylinders in which the relation of length to diameter varied between very extended limits. These are the conclusions of M. Mascart's investigations. In general, when a magnetic and isotropic body is of any form whatever, there exists three rectangular directions for which the magnetisation is parallel to the external field with different coefficients, f, f_1, and f_2. These coefficients have the same properties as the coefficients of magnetisation of a sphere of an anisotropic substance which is only feebly magnetic. Let us suppose, for example, that we have f greater than f_1, and that the body is movable round an axis parallel to the direction f_2, in a field of which the component perpendicular to this axis is H. Calling the volume of the body V, and α the angle which the field makes with the direction f, the movement of the couple due to the action of the field is

$$C = V\,(f - f_1)\,H^2 \sin\alpha \cos\alpha.$$

One easily sees that the magnetisation may be considered as the superposition of two others, one constant f_1 H, parallel to to the field H, and producing no couple, the other $(f - f_1)$ H cos α, fixed in regard to the body, and parallel to the direction of greatest magnetisation. This latter is also sensibly constant for small deviations. Such is the case for a magnet which oscillates under the earth's influence. If one wishes to take into account the induced magnetism, one ought then, strictly speaking, to add to the rigid magnetisation a magnetisation of the same sign $(f - f_1)$ H, proportional to the difference of the coefficients relative to the length of the magnet, and to the perpendicular direction. We may add that for steel the mean coefficient of longitudinal magnetisation is much more feeble than for soft iron, which contributes to increase the importance of the transversal magnetisation.

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CORRESPONDENCE.

THE POST OFFICE AND THE TELEPHONE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have read the reports of Mr. Preece's paper before the Society of Telegraph-Engineers with some surprise. It certainly seems a little strange to me, considering the *wonderful* perfection of the Post Office as laid down by Mr. Preece, that they have not got more subscribers, and also that in those towns where they have opened exchanges—with the exception of Newcastle—they have, I believe, been beaten by the private companies. Mr. Preece holds up the system of Newcastle as an example of perfection in telephony; but if the Post Office are so proud of their arrangements, it seems strange that they will not allow anyone with a knowledge of telephony to see their apparatus, while Mr. Preece has, I believe, visited many of the principal exchanges of the private companies. I should like to know what improvements have been made by the Postal Telegraph-Engineers in telephony; because, though I have had considerable experience of this work, I cannot at present think of any. I agree with the remarks of Mr. Preece that the telephone has been stifled by a "grasping monopoly." Perhaps when Mr. Preece made this remark he was thinking of Newcastle, where a private company opened an exchange, and obtained considerably over a hundred subscribers. The Post Office authorities compelled the company to close their exchange, and then canvassed the town, the company's exchange being closed for about twelve months. This I think is a fair example of a "grasping monopoly." But this is not all. The Post Office finding that they could not stop the private companies, have seriously interfered with their establishing that trunk communication between towns of which Mr. Preece seems to think so highly. This, no doubt, has resulted in delay, but the opposition of the private company to this "grasping monopoly" will probably yet be found inconvenient.—Yours, &c.,

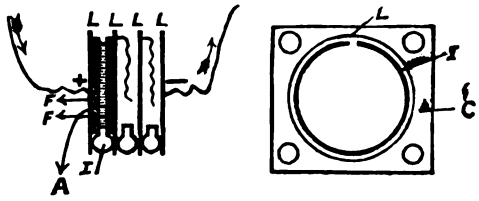
SEABEE.

ACCUMULATOR CONSTRUCTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am thinking of constructing an accumulator of the following construction, and should be glad of any suggestions or opinions upon it from any of your numerous correspondents as to its practical value.

In the accompanying sketch L L L L are comparatively thin



lead discs; F F are discs of flannel, felt, or "fearnought," and are slightly smaller, one pressing lightly against the side of each plate; A is the acid between the plates; I the india rubber ring (with a flange to separate the bottoms of the "fearnought" pieces), which makes the cell watertight all round with the exception of a small hole at top for filling.

The cell is bolted together by a cast-iron plate C at each end, with long bolts passing outside cells and insulated from the disc at one end. The connections are made to the discs and the current is sent right through the cell, thus oxidising and hydrogenising the two sides of each disc respectively, the result being that the cell acts as a voltaic pile of several elements, and gives a considerable E.M.F. and a small current. Also, there are no troublesome connections to make, or get out of contact, for the current is sent "broadside on" through each plate. The cell can therefore be used for one or two incandescent lamps of high E.M.F., which an ordinary cell cannot do on account of its low E.M.F. The internal resistance and storage capacity can be varied by using plates of greater area; or by coupling two or more of these cells parallel. The object of the "fearnought" is to prevent the oxide from falling down and short circuiting at the bottom of the cell, also to make the cell very portable. Hoping you will be able to insert this in your interesting paper.—Yours, &c.

A CONSTANT SUBSCRIBER.

THE PHONOPLEX.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: After having read the article inserted in your number of the 7th inst. on the "Edison Phonoplex," I thought the following might prove of interest.

In using the telephone in the place of a sounder I found that the sounds emitted from the former were improved by substituting for the mica diaphragm a plate of the ordinary metal used for making tins, &c., and raising in the centre of this plate a sort of blister by working the plate backwards and forwards with the forefinger and thumb. This blister (if I may be allowed the term) being in the centre of the plate rests exactly over the magnet of the telephone, so that every current sent through the coil round the magnet causes the magnet to attract this blister, and a sharp "snap" to proceed from the telephone as the result of the attraction. On the circuit being opened the blister springs back, making a decidedly louder "snap." The Morse signals were read according to the duration between each "snap." A primary current was used, but I see no reason why an induced current would not be equally applicable.

I should like further to mention that different tones were produced from the same telephone and plate by arranging various thin pieces of metal under or above the plate at the sides, where the mouthpiece presses on the plate, and also by placing thin pieces of metal across the plate. Not having the necessary mechanical skill, I was unable to adjust the diaphragm permanently, and seldom obtained two similar tones, and had to revert to the blistered plate simply for practicable working. It will be observed that the principle of the above is similar to that of the "pin and ring" arrangement described in your article, and if further developed by skilled workmanship might lead to useful results.—Yours, &c.,

Villa Real, Algarve, Portugal, May 18, 1886. L. C.

ELECTRIC BELLS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have read with great interest the article in last week's copy of your valuable paper on "Practical Electricity for Amateurs," describing the action of the continuous bells.

As this form of continuous action has many serious inconveniences and defects, I beg to bring to your notice an entirely new form, designed and patented by my firm. In place of the drop relay described in Figure 7 we use an ordinary relay, connected in the usual way, but with this addition—the coil is connected so as to form a shunt circuit between the terminals of the bell. It will readily be seen that on the relay being closed and a current flowing through the bell, part of the current is shunted through the relay, thus keeping the circuit closed. In the case of bells working with a relay, under ordinary circumstances we wind the relay with two wires, the primary or first layers being connected direct to line, and the secondary or second layers in the shunt circuit. The advantages of this simple plan are obvious, as the bell can be made continuous or not at will, and can be stopped and reset from any distance by simply breaking the circuit or short-circuiting the relay. This can be effected by an ordinary press or switch.

Trusting you will excuse this rather lengthy letter.—Yours, &c.,

C. B. CALLOW,

London, E.C., May 25, 1886. (Eck, Callow and Co.)

THE SOLDERING OF WIRES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of the 14th inst., on p. 6, in an article on "Practical Electricity for Amateurs," you say, respecting the

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soldering of wires, "*never use spirits.*" I have often seen similar advice elsewhere, but never a reason for giving it. If you would kindly say *why* with such emphasis the use of spirits is forbidden, the information would perhaps be acceptable to others as well as to—Yours, &c.,

May 26, 1886. AN AMATEUR.

A LEGAL QUESTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Could you or any of your readers kindly inform me if I can be prosecuted for using, in my own private business, a pair of telephones, same kind as the National Company's instruments, but which I can buy outright in Berlin for a low price?—Yours, &c., ENQUIRER.

Dundee, May 22, 1886.

THE LAW OF THE ELECTRO-MAGNET.

Dr. Frölich, in the *Electrotechnische Zeitschrift*, referring to Prof. Silvanus Thompson's article in the *Phil. Mag.* of January, 1886, says that he by comparison of the formula arrived at experimentally by Dr. Frölich with that arrived at theoretically by Lamont, suggests that the former represents the true law of the electro-magnet.

By the theory of Lamont the increase of the magnetism with increase of current strength is proportional to the difference between the magnetism actually present and the maximum possible value of the same. Let m denote the magnetism present, M the maximum value which this can reach, x the product of current by numbers of coils, k a coefficient which expresses the rise of the magnetism at first. Then, according to Lamont,

$$\frac{d\,m}{d\,x} = k\,(\mathrm{M} - m),$$

whence $$m = \mathrm{M}\,(1 - e^{-kx})$$

According to Dr. Frölich

$$m = \mathrm{M}\,\frac{k\,x}{1 + k\,x},$$

or, developing in powers of x, the two formulæ become respectively

$$m = \mathrm{M}\,k\,x\left(1 - \frac{k\,x}{2} + \frac{k^2\,x^2}{6} \quad . \quad . \quad . \quad . \quad . \quad . \right)$$

$$m = \mathrm{M}\,k\,x\quad (1 - k\,x + k^2\,x^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad)$$

Prof. Thompson thinks that these two developments nearly agree, and that this fact supports his view.

Now Lamont's formula and its development are for all values of the current, whilst the development above given of Frölich's is only true when $k\,x$ is less than 1. For $k\,x > 1$ the development is

$$m = \frac{\mathrm{M}}{1 + \frac{1}{k\,x}} = \mathrm{M}\left(1 - \frac{1}{k\,x} + \frac{1}{k^2 x^2} \quad . \quad . \quad . \quad . \quad . \quad . \right)$$

and this has nothing in common with the development of Lamont's formula.

He goes on to show that, if his formula were theoretically true, the increase of the magnetism with increase of current would be proportional, not to $(\mathrm{M} - m)$, but to this quantity squared.

As an experimental test between the two theories, he refers to the experiments of Prof. Von Waltenhofen with a flat-ring machine with direct winding, and no current in the armature.

In these experiments the value of m, obtained experimentally, agreed far better with that calculated from his than with that calculated from Lamont's formula.

FORMULÆ ON MAGNETIC MOMENT.*

Let us suppose that some one wishes to solve the following problem:—

Given an iron-cylinder (for example, the branch electro-magnet of a dynamo machine) of a certain diameter and length and with a certain number of windings of wire, what is the magnetic moment (when saturation is reached) which will be evoked by a current of so many amperes?

The magnetic moment in such a case is difficult to determine from the laws and experiments given in the treatises of those experimenters who have occupied themselves with the subject.

In the calculation of the answer to the above question, one would have to have regard to

I. The variation of the magnetic moment with the product of the number of windings and the strength of the current.

II. The (according to Dub) direct variation of the magnetic moment with the square root of the diameter.

III. The (also according to Dub) effective variation in cases of this kind with the $\frac{3}{2}$ power of the length of the bar.

The practical usefulness of the empirical formulæ at the command of electro-magnetism has hitherto been so small that you find among practical men little estimation for these dogmas of science, and the reason is that the constant coefficients in the formulæ have not been determined. The formulæ which represent the empirical laws of Lenz, Jacobi, Müller, and Dub contain factors which universally consist of functions of the dimensions of the bar and constants. But the required constant factors have not yet been ascertained.

The three laws given above are represented by the formulæ

$$y = \mathrm{C}\,x$$

$$y = c\,\sqrt{d}\,x$$

$$y = m\,l^{\frac{3}{2}}\,x$$

where y is the moment of the magnet, d the diameter of the bar, and l its length.

The latter two formulæ may be reduced to the single one

$$y = k\,\sqrt{l^3 d}\,.\,x$$

To eliminate the constant k we must make an experiment which will give us the moment y', which a certain bar of length l' and diameter d' acquired when it was magnetised by means of a coil of n' windings, through which passed a current of i' amperes. We shall then have the relation

$$\frac{y}{y'} = \frac{\sqrt{l^3 d}\,.\,n\,.\,i}{\sqrt{l'^3 d'}\,.\,n'\,.\,i'}$$

and can hence determine y.

To render this experiment unnecessary for the practitioner to make, the author by various sets of experiments which have been published has determined k, for which he gives as a rough value 0 135.

Thus we have

$$y = 0{\cdot}135\,\sqrt{l^3 d}\,.\,n\,.\,i.$$

But this formula is only true till saturation is attained. The author's experiments on the magnetisability of iron and steel give the magnetic maximum—that is, the highest attainable magnetisation in a field of infinitely great intensity, as 212·5 units of the C. G. S. system per gramme. Accordingly the magnetic moment of an iron cylinder of length l, and of thickness d (given in centimetres), when magnetised to saturation, is

$$y' = 212{\cdot}5 \times \frac{\pi}{4}\,l d^2 \times 7{\cdot}78$$

if the specific density of iron is taken as 7·78.

The quotient of the actual magnetic moment present by the magnetic moment thus calculated, or $\frac{y}{y'}$, the author has called the "degree of saturation."

* Abstract of a paper by Dr. A. v. Waltenhofen in the *Centralblatt für Electrotechnick.*

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LEGAL INTELLIGENCE.

Edison and Swan United Electric Light Company v. Woodhouse and Rawson.

ACTION II.

The trial of a second action, substantially between the same parties, was commenced on Thursday, before Mr. Justice BUTT. This action related to a patent of a communication from America of an invention for improving the carbon burner of an electric lamp by solidifying the carbon employed, and at the same time rendering it uniform as to thickness. By means of subjecting it to an atmosphere of hydro-carbon vapour under heat the thin parts of the carbon become of higher temperature than the other parts and receive a greater deposit out of the vapour, and thus the thickness is made uniform.

Sir Frederick Bramwell, Dr. Hopkinson, and Dr. Tidy were again examined on behalf of the plaintiffs.

The defendants called no witnesses.

The trial was continued on Saturday, and on Monday the SOLICITOR-GENERAL opened the case for the defendants and concluded his speech. He began by saying he did not find it necessary to adduce any oral evidence of his own, having brought out in cross-examination all the facts he thought necessary to his case. The patent in this action is one which was first taken out in America and was patented in this country in American form. American patents, it seems, on account of some diversity of the laws of the two countries, are frequently much longer, and contain more claims than the English patents do. The patent has been amended, as is usual in such cases, and a large number of claims disclaimed, leaving in the result three only—one for a method, described in the specification, of preparing the illuminating part of an electric lamp by heating it by means of an electric current while it is surrounded by a carbon gas or liquid; another for a material for the manufacture of illuminating conductors; and the third for a method of getting rid of occluded gases from the illuminating part of the lamp, combined with a method of previously preparing it. The material is prepared by subjecting it in a hydro-carbon or some other suitable carbon atmosphere or liquid to great heat, by means of an electric current. By this means the thinnest part of the material (having greatest electrical resistance) becomes hottest, carbon is deposited in the pores of the material and on its surface, in greater quantities on the hotter parts, and a dense and uniform carbon is produced; the nature of the carbon is changed to a graphite kind, which is specially suitable for the purpose. Three prior publications were relied on to avoid the patent—in the first place, certain published experiments by Mr. Justice Grove with respect to an improved eudiometer by means of an electric current, in which a carbon deposit was obtained; in the second place some researches of Desprez in 1849, well known in the chemical world, for the purpose of showing that it was possible to fuse and evaporate carbon; and in the third place a communication by Sidot in 1870, in which he described a method of solidifying carbon, and in which he gives electric lighting (not mentioning incandescent lighting) as a purpose for which his material could be applied. Among the arguments that the Solicitor-General adduced to avoid the patent were, that on the construction of the claims they seek to protect the method of preparing the material and the material generally; that in the specification the patentees have asserted, honestly no doubt, that they have invented what they have not invented, and that, as matter of law, that would be enough to avoid the patent; and, further, that the claims are merely for the application of well-known processes and articles to a particular thing, an application which does not result from such exercise of inventive power as to be the proper subject-matter of a patent.

Mr. ASTON replied on behalf of the plaintiffs, and directed the attention of the Court principally to the publications of Messrs. Despretz and Sidot, and reviewed the evidence that had been adduced bearing upon the difference between the knowledge the French writers possessed and the directions given by Cheesborough with regard to incandescent lighting, with the object of showing that in those publications there was no anticipation of the patent in them, the defence set up by the defendants being that there was. He claimed not only that the process adopted by Cheesborough was a new process, but that the material he employed was a new material, and that the patent of Cheesborough was a good one, which had been infringed upon by the defendants.

Mr. Justice BUTT, in delivering judgment on Tuesday morning, said: The plaintiffs in this action are the owners of patent No. 4,847, dated 24th November, 1878, as amended by disclaimer of the 12th Nov., 1884. The claim is against the defendants for an infringement of their patent. The patent is one for making the carbon conductors of electric lamps. The process by which the desired result is obtained is to my mind one of singular beauty and efficacy. The principal features of the process are these. A pencil of ordinary carbon is immersed in a hydro-carbon gas or liquid. A strong electric current is passed through the carbon, and in the course of its treatment the carbon is subjected to a gradual increase of the current of electricity. The defects in ordinary carbons for electric lighting, and the remedies applied by his process are thus stated by the patentee in his specification:—"As is well-known, carbon suitable for electric lighting by the voltaic arc is naturally produced in gas retorts, but generally the rods of carbon used in the regulator lamps so called are moulded from a powdered material. Neither the one nor the other quality of carbon is suitable for electric lighting by incandescence. In both there is a lack of homogeneity. The pencil is not sufficiently hard and dense, because in the first place the heat required to produce the proper character of carbon is as high as 7,000 degrees Farenheit. Such a heat is not obtainable in a retort. In the second place the mechanical sub-divisions of the material and the pressure necessary to produce the perfect article are practically unattainable. A carbon of the ordinary sort when heated by an electric current exhibits points and lines of unequal brilliancy. Carbons prepared by this process, when so heated, glow with a uniform brilliancy throughout." The principal part of that relates to the objections to the use of the ordinary carbon for the electric light. Now comes the improvement. "It has been found that a pencil of carbon immersed in hydro-carbon gas or liquid, and heated to an extremely high temperature by the voltaic current, is not itself attacked, but decomposes the surrounding matter, the carbon of which enters and fills up its pores to an extent impossible except to matter in a very attenuated state, and deposits a perfectly homogeneous layer, generally of a bright gray colour, upon the exterior surfaces. As the carbon increases in size more current is required to maintain its temperature, and if the current is gradually increased in accordance with the demand for it there is apparently no limit to the increase in the mass of homogeneousness of the deposit. The carbon pencils may be cut from this deposit, or the original pencil with its coating may be used in the lamps." In this process it will be seen that the carbon is never in contact with the liquid in which it is immersed, but surrounded by a carbonic gas of very high temperature. Beeswax, balsam, and most oils, if pure, operate satisfactorily—almost any hydro-carbon, in fact, will answer. The peculiar merit of the invention consists in a well nigh perfect adaptation of the means employed to the end aimed at, and this by the automatic action of the materials employed when subjected to intense heat generated by the passage of an electric current. As pointed out, in an ordinary piece of carbon subjected to a high electric current there are observed points and lines of unequal brilliancy. The most brilliant parts are those where the carbon has the smallest sectional area, the resistance of the carbon to the passage of the electric current, and, therefore, the heat being in inverse proportion to the size of the cross section of the carbon. At these points of greatest heat the deposition of the carbonaceous matter by means of this hydro-carbon gas goes on most actively, and so equalises the carbon, which is also made more dense by the operation. That being the patent I do not understand that there is any serious dispute, that, if valid, it has been infringed by the defendants. The answer to the action is not that they have not used the process and the material in question, but that they had a perfect right so to do, because the patent is invalid, inasmuch as the process by which the material was made was known long before the date of the patent in question; that the process and the material were common property, which the public and they, as part of the public, were entitled to apply to any purpose for electric lighting, by incandescence amongst other things. The question arises, therefore, Was the process known before Cheesborough's specification? That appears to me to be the principal question in the case, though there are some other objections made by the Solicitor-General to the validity of this patent. With these objections I propose to deal in the first instance. In the first place a reference was made by the Solicitor-General to lines 5 and 6 of page 12 of the specification. In stating the objects of the invention the patentee there says, after having detailed some others: "To obviate these several difficulties is the object of this invention. To charge the lamp which it is preferred to employ nitrogen gas, and this is produced in the lamp by an improved process in a state of great purity." It is objected that there is no direction in the course of the specification given to the public how to make that improved nitrogen gas, but on looking to the claim, or that part of it which refers to the passage I have read, namely, claim No. 3, I do not see that any claim is made for an improved nitrogen gas. The words of Claim 3 are as follows:—"The herein before described method of preparing the illuminating part of an electric lamp consisting in first obtaining a solid globe containing deposit of carbon by electric action, as set forth, and subsequently, when it is charged with a carbon preservative atmosphere before the flow of such preservative atmosphere has ceased." The nitrogen gas, as I understand it, is there referred to in these words:—"It is charged with a carbon preservative atmosphere." In another part of the specification he suggested that anybody knows how to get or how to make the material used. I point out in the first instance that there is no claim, strictly so called, to the use of the improved nitrogen gas. But on page 14, line 34, of the specification these words are used:—"The lamp being set up, the next important thing is to charge it with an atmosphere which will prevent the consumption of the carbon." And the detailed description of charging the lamp is as follows. Now before that word process he had in the first instance the word "improved"—"improved process" was used originally—"of charging the lamp," which, he said, is as follows. He struck out that word "improved." But it may be said, and I think it was said, "That is all very well, but that refers not to the manufacture or the making of the improved nitrogen gas, but to the charging of the lamp." Well, I cannot agree that that refers only to the charge of the lamp when the gas is made, because when I go on to another part of the specification, on page 14, directly afterwards, I find this "the detailed description of the process"—originally it was "improved process"—of charging the lamp is as follows:—"Various methods of manufacturing the nitrogen gas are well known. Having dried and purified the gas until it stands the test, it is placed in a dry receiver, preferably a bag of vulcanised india rubber." There it is manifest that in starting to describe the charging of the lamp the very first thing he does is to tell you what gases to use. Therefore I think the objection properly considered amounts to little more than a verbal criticism, and there is no substance in it. Secondly, it is said that the patent is void because it describes various methods of making the material, some of which methods will not answer; in other words, that it was misleading the public. The first claim is in these words, "The herein described method of preparing the illuminating part of the electric lamp consisting of electrically heating the same while it is surrounded by the carbon gas or liquid." Now, the "herein described method" mentioned in that claim refers to a passage at page 15

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of the specification. It is the passage I have read once already, but to which I shall have to refer more than once in the course of my judgment. "It has been found," it says, "that a pencil of carbon immersed in a hydro-carbon gas or liquid, and heated to an extremely high temperature by the voltaic current is not itself in contact, but decomposes the surrounding matter, the carbon of which enters and fills the pores," and so on. And then further on at line 44 he says, "In this process it will be seen that the carbon is never in contact with the liquid in which it is immersed, but surrounded by a carbon gas of very high temperature, beeswax, balsam," and so on. Then he says, "Almost any hydro-carbon, in fact, will answer." We have, therefore, three terms used. He speaks of a hydro-carbon gas, he speaks of a hydro-carbon gas, and of a carbonic gas, and I do not think from the evidence that he meant exactly what he said in using any one of these expressions. Dr. Tidy, I think, said—in answer to the Solicitor-General it was—that the term hydro-carbon gas, as used by him here, is entirely an erroneous one, strictly speaking, in a chemical sense; because, strictly speaking, as I understand the matter, hydro-carbon gas consists of carbon and hydrogen alone, without any other element mingled with it. That is clearly what the patentee was not referring to. I do not know whether very much turns upon that, but when you come to the other two things mentioned—carbonic gas or carbon gas—probably the same thing is indicated. It is said but that will include some gases which, if applied, would not produce the result at all. "It would not," says the Solicitor-General—and he is warranted in the assertion by the answers he got from Dr. Tidy and I think one of the other scientific witnesses—"it would not produce the effect, but would include both carbonic acid and carbonic oxide, and if you use either one of these two ingredients you would fail to get the deposit which you are seeking to get on to your carbon pencil, and so the whole operation would fail." Well, if the specification is really to be read as a direction to the public to use either one of these gases then I should agree that the process as described, which is a futile process, would be misleading to the public. But then I do not really think he meant that, and I think I need not give my own reasons for saying so, because I think I can get them better from the evidence of one or two of the witnesses. Dr. Hopkinson, I think, in his cross-examination says:—"In the sense I understand that the patentee used the word carbonic gas, which would include carbonic oxide and carbonic acid, carbonic oxide and carbonic acid would not effect the purpose of making the deposit." Then, I find Dr. Tidy is examined on the point, and he is asked with reference to the expression "hydro-carbon gas or liquid," "is that a correct expression?" He says:—"From what follows, objection may be taken to it undoubtedly from a strictly chemical standpoint, because, in strictly chemical language we understand by a hydro-carbon a body that contains only carbon and hydrogen, and nothing else. But, I think, by the term hydro-carbon in this specification is clearly meant a body that contains carbon and hydrogen. The word is not used, to my mind, strictly in a chemical sense in the specification, but as a body that contains carbon and hydrogen, though not carbon and hydrogen exclusively," &c. Then, a little further on, he goes on to other points, and Mr. Aston asked him whether reading this specification on the principle of fairly understanding it, any person would be led to try carbonic oxide or carbonic acid, to which he replies, "No, I should not think so. I cannot imagine that anybody would ever dream of trying it. First of all, you could not get a carbon deposit from them by the process that is suggested. Any text book would have told them that." When he comes to be cross-examined by the Solicitor-General he says, "It is not an expression which I should have adopted myself." "Do you not understand by the expression carbon gas, gas of which carbon is one of the constituent elements?" "I do." "Would not carbonic acid be a carbon gas in that sense?" "In that sense, certainly." Now it certainly does appear to me, having regard to the expression used, having regard to Dr. Tidy's statement, which is absolutely uncontradicted, that no man in his senses, no man with ordinary knowledge in his senses would think of applying carbonic oxide or carbonic acid to this operation. It seems to me it would be an extremely hard and unjust construction or interpretation of this specification to hold that the patentee had invited the public to use carbonic oxide or carbonic acid, and so have rendered his patent void. I now come to what I regard as the real question before us. Was this process known before Mr. Cheesborough's specification? A great number of publications have been referred to by the defendants in support of their contention that neither process nor material was new. I think the only publications requiring serious consideration in these relations are those of M. Sidot, which were made in the year 1870, and of M. Despretz at a still earlier period in 1849. I will take Sidot's paper first. No doubt in the course of some experiments he was making, not with a view to electric light, as I understand it, M. Sidot produced a material resembling that which results from the process of the patentee. But it appears to me impossible on the evidence to say that he either described a process that would make the material, or that he did make the material produced by Mr. Cheesborough's process. The evidence satisfies me that the desired result cannot be obtained by the application of external or furnace heat, as contradistinguished from heat produced by electric action as used by Mr. Cheesborough. Sir Frederick Bramwell in his evidence deals with the matter, and I will refer shortly to what he says on the subject. He points out this in substance, that uniformity of heat produced uniformity of deposit per unit of the area, and that is what you do not want in your process for producing a carbon conductor described by Mr. Chessborough. Then there is a passage of at least equal importance in Prof. Dewar's evidence, to which I will now refer. Prof. Dewar is also asked about Sidot's experiments, and he says "Sidot's experiments show that the main deposit of a high heat is on the walls of the tube and not on the wood." "Some would deposit on the wood?" "I have no doubt some would." "Assuming that some would deposit on the wood, are you able to point out any difference in the carbon as the extra deposit put upon it by Sidot and the carbon which is the extra deposit put upon it by Cheesborough?" "I do not think they have anything in common. I have already stated that carbon produced by an electric action at high temperature, which is pointed out by Cheesborough, cannot be produced by furnace operations." It must be remembered that Sidot's operation was purely a furnace operation and nothing else—heat produced by fire from the outside. Prof. Dewar says, "I have said that all carbons necessarily contain hydrogen more or less along with other impurities. That produced by Sidot is carbon, more or less, but not the same material as the Cheesborough carbon. It is not in the same physical condition." That evidence is wholly uncontradicted. [The Solicitor-General pointed out that in cross-examinatiou Prof. Dewar admitted that it was a question of degree.] I fancy I recollect something about that, but I was under the impression that it was in regard to Despretz and not Sidot. However that may be, I think degree has everything to do with the matter, because I think in this electric conductor the degree in which you give it density is of importance, and if Sidot's will not do it I do not think Sidot's paper can be called an anticipation. I now come to Despretz's paper published in 1849. I have no doubt Despretz produced a material in substance very like if not identical with that used for the carbon conductor patented by Mr. Cheesborough, and he got the heat he supplied by means of an electric current. But there is one most important object obtained by the process patented by Mr. Cheesborough, which I think the defendants have failed to show that Despretz's process would yield. The principal object of this patent is to insure the filling up in the course of the treatment of the porous carbon, the porosity of ordinary carbon being a serious objection to its use for incandescent lighting. Now, one part of the process described in the specification is a gradual increase of the electric current. This was certainly no part of Despretz's process. It is an important matter that all or nearly all the witnesses referred to it as a matter of consequence, and Professor Dewar says it is necessary to cure the porosity of the carbon. My note on Professor Dewar's evidence on this point is as follows:—"He" (that is speaking of the patentee) "also points out a gradual increase of the intensity of the current. For Mr. Cheesborough's purpose you must have an intense electric current increased from a less intense one. I find no direction of all this in the anticipation that is in Despretz. Despretz used an enormous current, but he put out the whole at once, and it was not graduated." Then he goes on to Sidot: "I have experimented on Sidot's process, and I say the carbon produced by Sidot is not the same as Cheesborough's—not in the same physical condition. I say you cannot get Cheesborough's carbon from any process carried out by external heating." Then in coming to Despretz he says, "There is nothing in Despretz's papers which would suggest its application to the purpose of getting a good carbon conductor for an incandescent lamp. I have not the slightest doubt but the porosity of the carbon was not cured by Despretz's process, because he did not apply the graduated current." [The Solicitor-General here drew his lordship's attention to apparently contradictory statements on the part of the witness.] I have read all this evidence, and I am trying to understand it as far as I am able. I have read all these passages, and I do not conceal from myself at all that in the evidence of these gentlemen in one part or another there are discrepancies in the text; but the conclusion to which I have come on the whole is that Prof. Dewar, taking the whole of his evidence, taking his examination and cross-examination, intended to abide by this, that you could not cure the porosity without a gradually increasing current. If I am wrong upon that point the defendants will have an opportunity of reviewing the whole of the evidence and setting me right hereafter. Taking the whole evidence I certainly do not feel that I could come to the conclusion that M. Despretz, in the paper in question, has described a process which would enable a competent workman to arrive at the result Mr. Cheesborough has attained. Had I thought otherwise I should have taken time to consider whether the admitted publications in England (for it is admitted in M. Despretz's paper) would have been what is called an anticipation of Mr. Cheesborough's invention. M. Despretz's paper is entitled "Volatilisation of Carbon." It relates to experiments on the volatilisation of carbon—a process the very reverse, as I understand it, which an electrician would desire to bring about for the purpose of electric lighting. The material alleged to be identical with that of Mr. Cheesborough's improved carbon conductor was not a material M. Despretz was seeking to obtain. It came upon him as a surprise, as a disturbing element in the course of his experiments, and interfered with the object he had in view, and its presence does not seem to have been regarded by him with any degree of satisfaction. Moreover, his experiment never seems to have been repeated from the year 1849 down to the time of Mr. Cheesborough's specification. Never during that interval is the material in question applied to any useful or practical purpose. I would here refer to one passage in Dr. Hopkinson's evidence. "Despretz's publication," he says, "has no reference to incandescent lighting, and would not be a publication to which an inventor of an electric incandescent lamp would go for information, and I think when he saw the title of that publication he would rather be deterred than invited to look into it" I am, therefore, of opinion that the invention which Mr. Cheesborough patented has not been anticipated by any prior publication of this process, that the patent sued on is valid, and as its user by the defendants is admitted, there is an infringement for which the plaintiffs are entitled to relief.

Mr. ASHTON made the usual application for an injunction in terms, and an account of the profits, the delivery up of the infringing articles, subject to any arrangement which might be made between the solicitors of the parties, and for costs on the higher scale.

His LORDSHIP acceded.

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SPECIAL NOTICE.

With this week's number of "The Electrician" is issued two double-page Illustrations of the Paddington Electric Light Installation.

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INCANDESCENT LAMPS.

The two legal decisions which have been given within the last few days with regard to the infringement of certain patents by Messrs. Woodhouse and Rawson are of the greatest interest to all connected with the electric light industry. These decisions have put an end to a period of uncertainty, and will no doubt play a very important part in the future progress of the industry. We are not at all sure that the profession as a whole was prepared for the verdict given. The general opinion seemed to be that both parties would gain a portion of their case; but it has ended otherwise, and the holders of the Edison and Cheesbrough patents have been successful at all points. It has now been legally decided that a pencil of carbon, no matter how fine, and a filament of carbon are not one and the same thing. Mr. Edison was the first to use the term "filament" in connection with patents, and Mr. Justice Butt—very justly we think—remarked that the question of the infringement of claim No. 2—that is a claim of the patent No. 4,576, the validity of which was under dispute—depends upon the meaning to be attached to the words in it, "a carbon filament." He went on to say, "If these words mean a carbon filament made as described in the patent, I should hold that there was no proof of its infringement. But I do not so interpret these words. I hold them to mean any carbon filament, however made, which possesses certain qualities or properties mentioned in the specification, or necessarily resulting from the description there given. To answer that description the carbon filament *must*, I think, *possess flexibility and resiliance*. It must be of small cross section offering a high degree of resistance to the passage of an electric current, and it must present but a small surface from which radiation can take place. I am disposed also to think (but on this I refrain from giving a decided opinion) that the degree of resistance must not be less than 100 ohms, as mentioned on page 3 of the specification. Taking the above to be a correct interpretation of the words 'a carbon filament' in Claim 2, it is clear that there has been an infringement of the patent by the defendants."

With regard to the second action the case of the plaintiffs always seemed fairly strong, and the result has created no surprise. At the conclusion of the trial—as will be seen from our report—the injunction asked for was granted. It is very doubtful whether the case will be carried any further, for the appeal would mean another period of uncertainty, and if unsuccessful a very greatly increased expense.

The position of the holders of the Edison, Swan; and Sawyer incandescent lamp patents is this, that they have obtained practically the position of monopolists. The "Sawyer" patent has been generally called throughout these proceedings the "Cheesbrough patent." There are other patents for incandescent lamps. The validity of a number of these would hang upon the decision which has been arrived at, the validity of others may still be disputed, and, in all probability, some will be agreed to be perfectly valid; but although this may be the case, the patents are for lamps which are not so commonly in use as those made under the patents discussed in the recent legal proceedings. There is a danger, then, that the holders of a monopoly may be ill-advised enough to act in such a manner as would, in the end, be greatly detrimental to the progress of electric lighting. We do not think this will be the case, but it is a condition of things which may arise, and which, therefore, cannot be overlooked. A patent gives to its holder a practical monopoly for a term of years; at the end of that term of years the process is open to the world. The holder of a valuable patent is a person or a company which has probably paid a very large sum to the patentee in order to obtain the right of using that patent during the 14 years over which he has the sole control. The purchaser hopes during that period to recoup himself for the initial outlay, and if the process involves manufacture, to obtain a good round sum annually as manufacturing profit, and interest upon the outlay. Unless, however, there is a demand for the article, the purchaser instead of obtaining a profit makes a loss. In the case of these special electrical patents under consideration, very large sums were paid to patentees and the promoters. Companies were formed with a very large capital, and the directors have to consider the interests of their shareholders.

It has been thought that success in these legal proceedings would probably lead to the increased cost of incandescent lamps, and as the renewal of lamps forms a considerable item in all installation work, would probably hinder the growth of such work. The contrary, however, has always seemed to us to be the more probable, and the legal question having once been settled, the holders of the patents will endeavour to pro-

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THE PADDINGTON INSTALLATION.

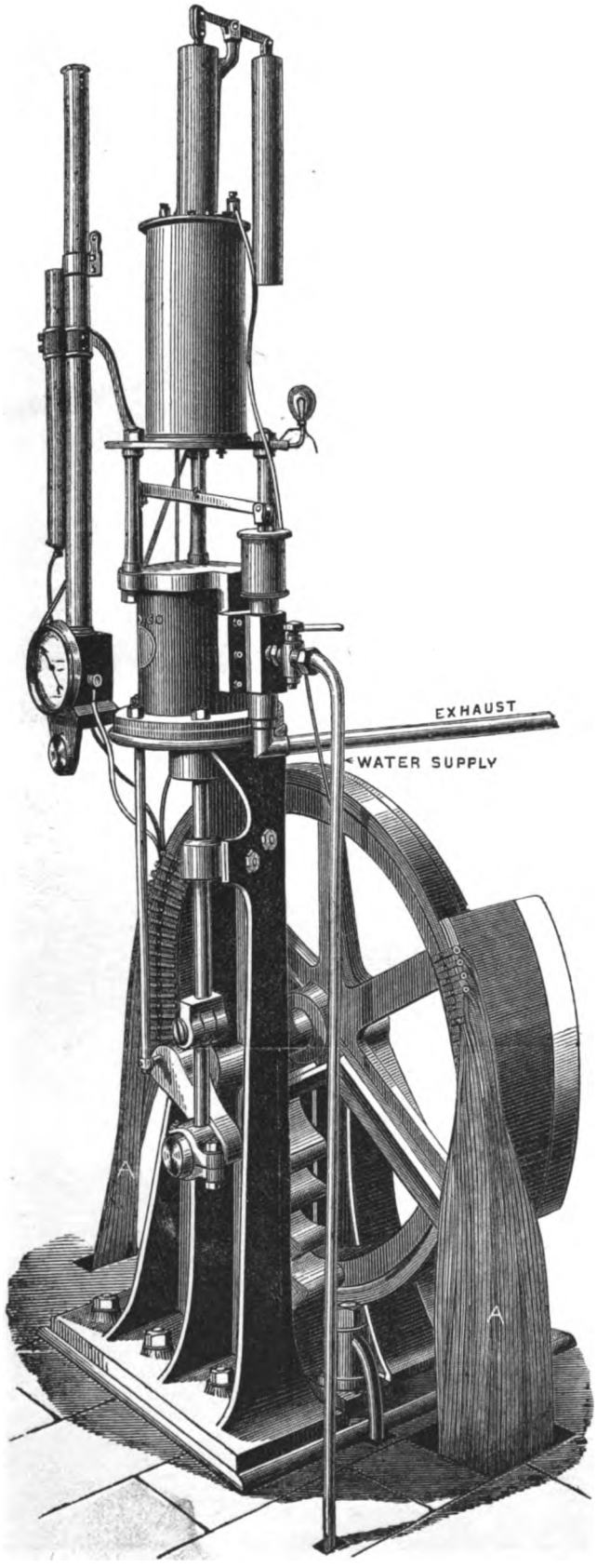

FIG. 1.—THE GORDON DIVIDED MAIN APPARATUS.
A A Bundles of Wires.

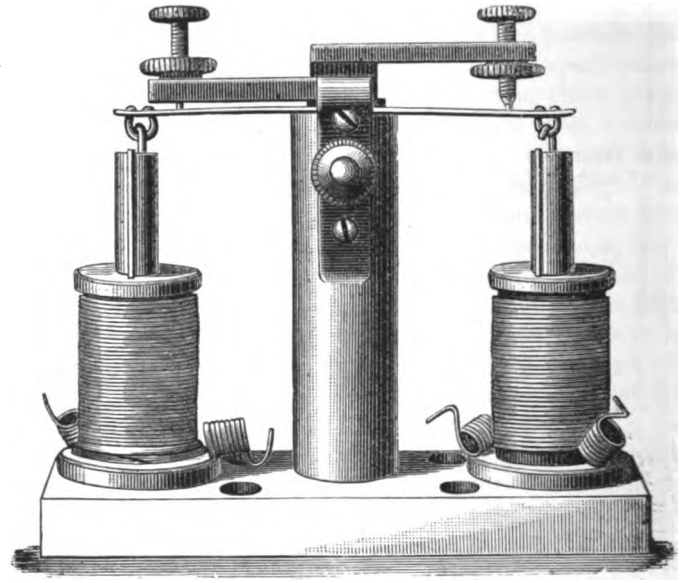

FIG. 7.—SIGNAL APPARATUS

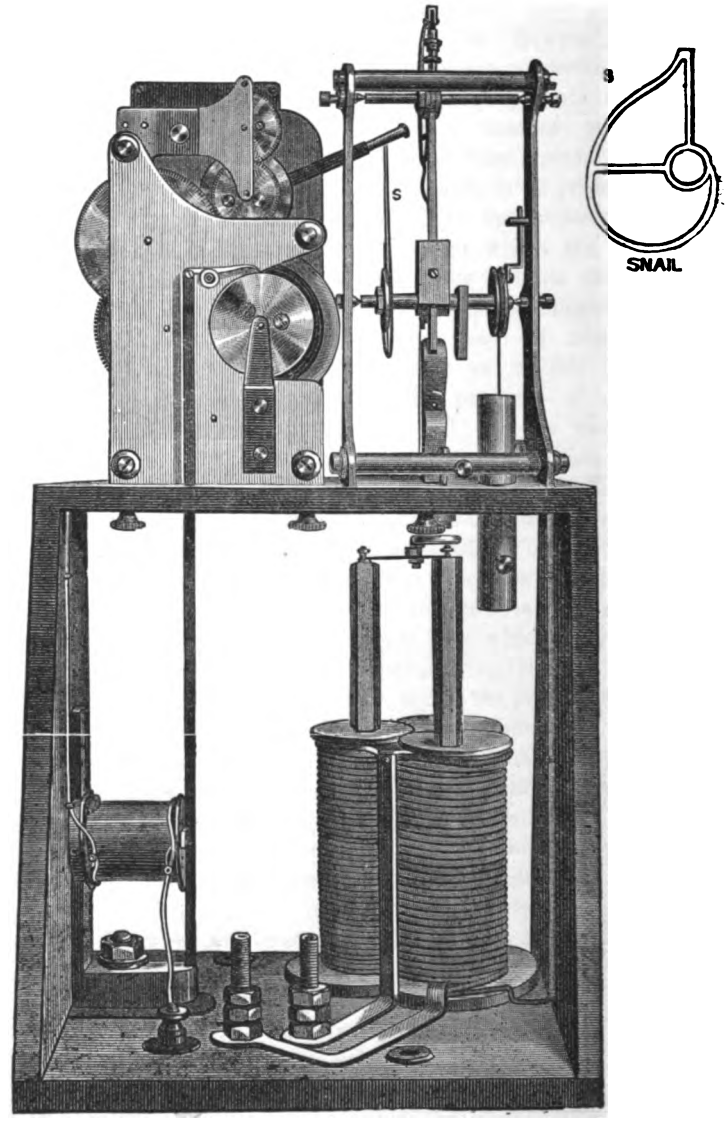

FIG. 8.—THE DOMESTIC METER

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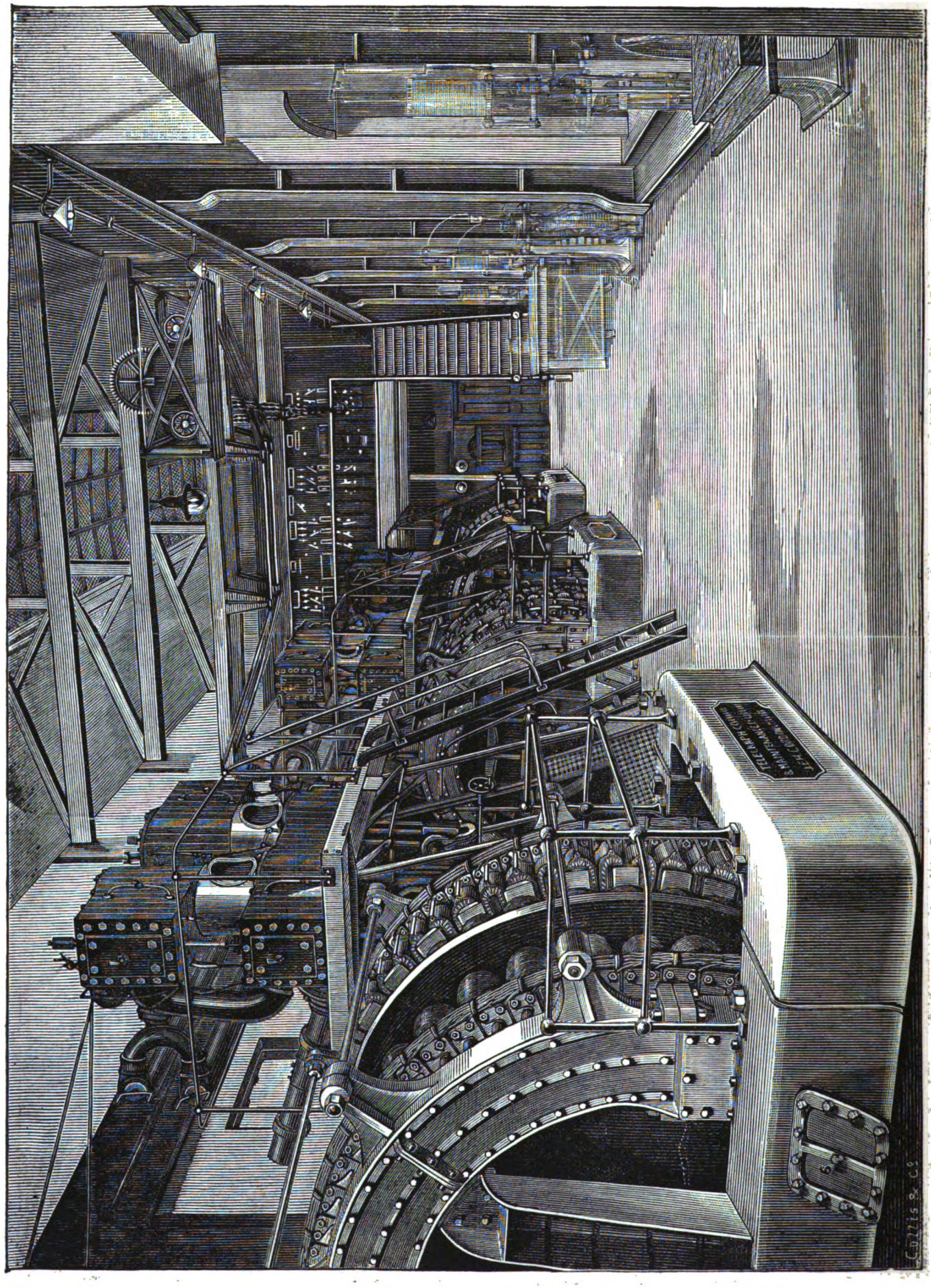

FIG. 2.—DYNAMO ROOM, PADDINGTON INSTALLATION. SHOWING THE THREE LARGE GORDON DYNAMOS.

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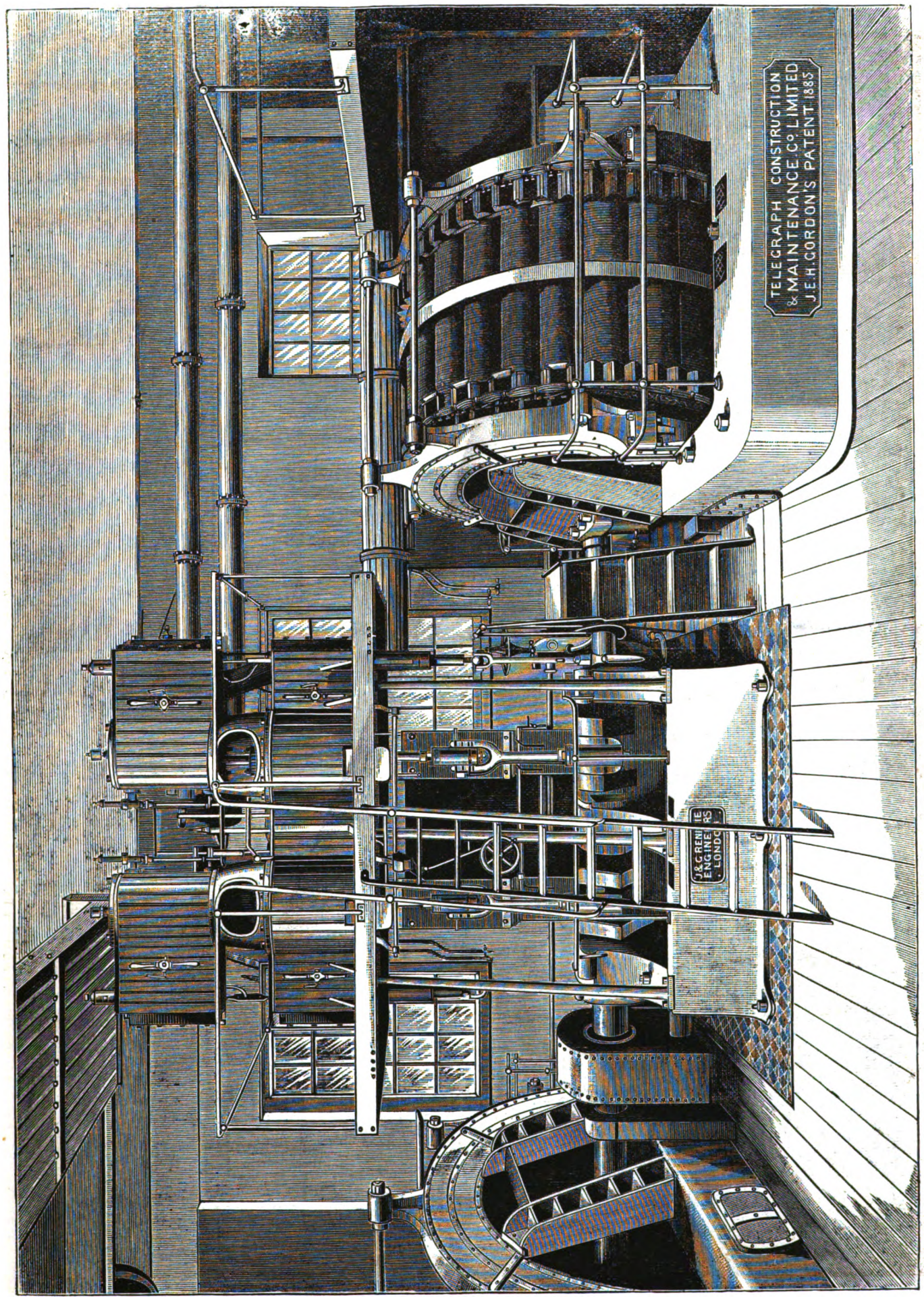

FIG. 3.—DYNAMO ROOM, PADDINGTON INSTALLATION. FRONT VIEW OF GORDON DYNAMO AND ENGINE.

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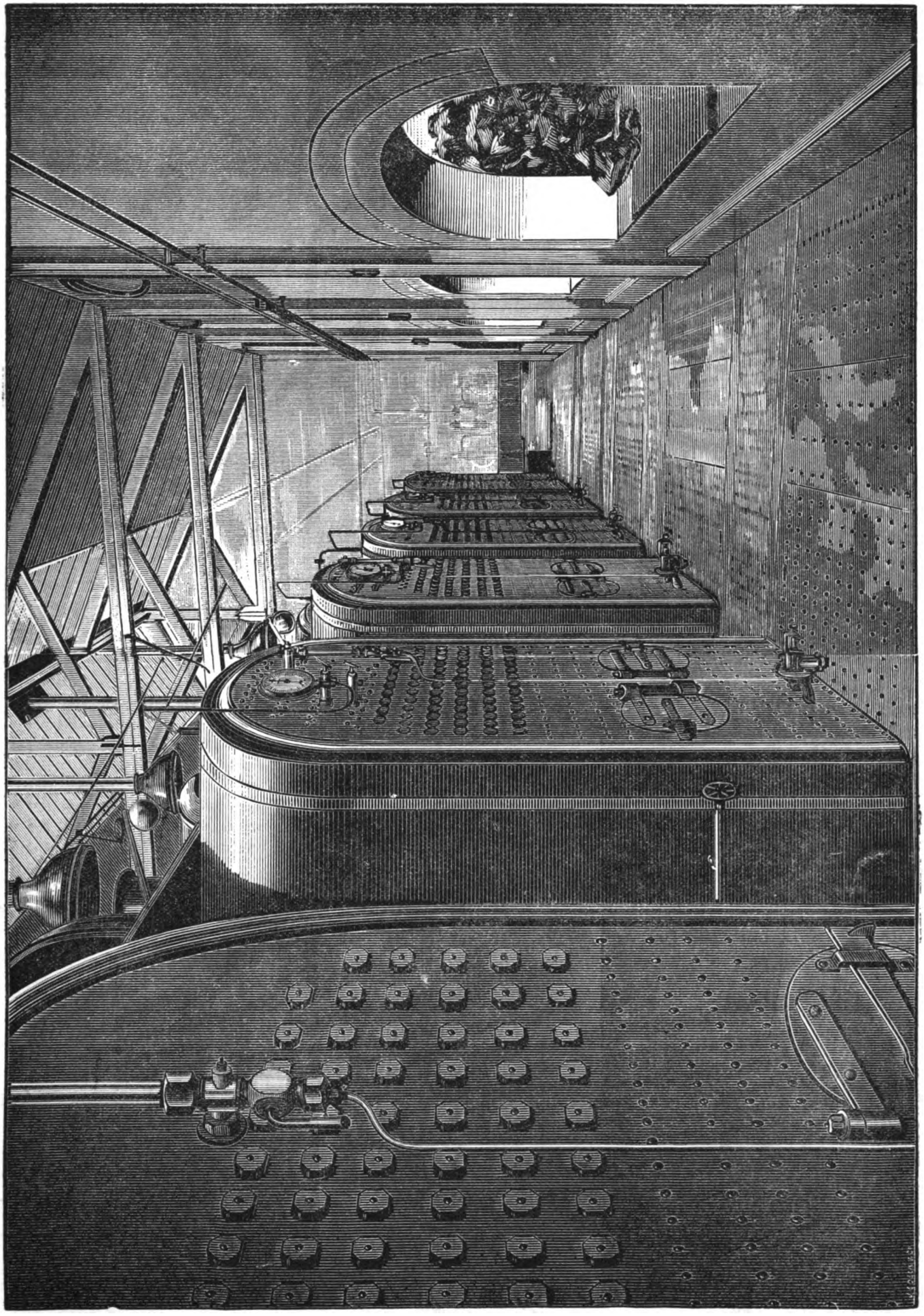

FIG. 9.—BOILER ROOM, PADDINGTON INSTALLATION.

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duce as good a lamp as is now produced and at as low a cost as possible in order that at the end of the period when the patent rights expire they may be practically supplying the whole world, and, having so very large a *clientèle*, will be in the position to laugh at all attempts to set up rival manufacturers of their particular speciality. Indeed, we have no reason to suppose but that improvements will still continue to be made in incandescent lamps, just as they have been made during the past two or three years, and that long before the period arrives when the patent rights expire, the manufacturers will have gained such an amount of experience, and have become so proficient in the production of lamps, that no new manufacturers could hope to be able to compete against them. There is no doubt that the life of an incandescent lamp depends very considerably upon the amount of care exercised in the various details of its manufacture, and in this case, as in most others, there are trade secrets altogether outside of anything in the patents.

Let us suppose for a moment that a monopoly should lead to carelessness in the construction of the lamps, and to a higher price being charged. The immediate result would be paralysis of the trade and a languishing demand till the patents expire, unless some new discovery supersedes the necessity of such lamps altogether. It will be easily seen that the definition of Mr. Justice Butt is open to some criticism, and it might be asked how far the Cruto and the Bernstein lamps come under this definition. The filaments of these lamps certainly possess flexibility and resiliance; but the surface of radiation, though small, is larger than that in what we may term the solid filament. The question of resistance does not play an important part in the definition, as that depends upon conditions, and can hardly be deemed a special property of the filament. Under the adverse circumstances suggested, greater attention would be paid to the development of arc lamps of comparatively small candle-power, and it is certain that if a good lamp of this kind could be successfully made there would be a large field for its use. Altogether, then, we think there is no reason to fear that monopoly will in any way endanger the progress of electric lighting. The most disagreeable feature is that monopolists are apt to be autocratic, and young firms, whose requirements may be small, are not always treated with that courtesy and consideration which is accorded to older firms, whose demands are much larger.

THE PADDINGTON INSTALLATION.

Time always works favourably for a good thing, and there is no exception to the rule in the matter of the electric light. Gradually, but surely, the civilised world is being educated, and fifty years hence no one will be able to imagine why in the earlier stages of operation there should have been any doubts or fears about the final result. In the initial stages the work falls into the hands of those who believe in themselves as much as in the matter they have to carry forward. The pioneers in electric lighting are necessarily self-confident men. They feel they can overcome the difficulties before them, and the result we see in continued advance. The successful lighting of Paddington Station and yard makes a distinct step in the onward progress. In our issue of Oct. 28, 1882, we illustrated and described the "largest dynamo in existence," which was constructed by the Telegraph Construction and Maintenance Company to the designs of Mr. J. E. H. Gordon. The dynamo was running at the works of the Company at Greenwich, and was used to generate the current required by the incandescent lamps used to light the works. From the experience gained with this experimental machine the company believed that they saw a solution for the great question of central lighting. We say "the great question," preferably we should say *the* question, for after all is said and done, unless electric lighting upon a large scale from central stations is proved practicable, the future of electric lighting is not worthy the attention of consumers or capitalists. Mr. Edison in New York has shown a certain modicum of success—but it is well known that his experience has been gained at a great expense, and that had he to design and carry out a similar installation he would proceed differently. Upon the Continent of Europe installations of 3,000 to 4,000 incandescent lamps are not unknown; then, in England we have seen what was done on the Holborn Viaduct, and what is done at Victoria and at the Kensington Exhibition. These have all been steps—none, however, so complete or emphatic as that at Paddington. No doubt the initial cost of the Paddington installation has been out of all proportion to the initial cost of a second similar piece of work. We are not, for the moment, troubled about questions of cost, nor should such questions enter into the discussion of success. At Paddington we find a small central building containing machinery for the generation of energy, which energy is distributed and utilised in the form of light on the one side as far as Westbourne Park Station; on the other side to the Great Western Hotel. The light is distributed over the hotel, the station offices, the station platform, the goods yard, the Royal Oak station to Westbourne Park station, platforms and offices, just as gas-light would be distributed from gasworks. The district is one and a half miles long and covers nearly 70 acres of ground. The success at Paddington, if it means anything, means that it is proved beyond cavil that an area enclosed within a circumference whose diameter is 1·5 miles can be supplied from a generating station in the centre of that area. The limit is not shown by these figures; they simply record facts. Within the district described there are over 4,200 points of light; in fact, there are 4,115 incandescent lamps of 25 candle-power each, 98 arc lamps of 3,500 candle-power each, and two arc lamps of 12,000 candle-power each, being by far the largest installation of mixed lights hitherto made.

The distribution of the incandescent lamps is as follows:—Passenger Station offices, 2,009; Great Western Hotel, 472; Goods Station offices, 458; Dynamo Centre (*i.e.*, offices near dynamo-house) and Royal Oak Station, 617; Locomotive and Westbourne Park Stations, 559, or a total of 4,115 lamps. The distribution of the arc lamps is:—Locomotive Station, 5; Dynamo Centre, 10; Goods Station, 34; Passenger Station, 48; and 2 at the hotel corner, making 98 in all. The total light given is said to be equivalent to about 30,000 gaslights.

The difficulties of successfully carrying out such an installation were manifold. This may easily be imagined when it is remembered that it is the first attempt that has been made to lay a great system of underground mains in a busy railway station without in any way interrupting the traffic for a single hour. In parts of the station—particularly in the goods department—tunnels had to be driven for laying the mains, as the contractors could not be allowed to keep the trenches open at all. In other parts, notably in the Westbourne Park main, they seldom got a full minute's work undisturbed by passing trains. It may also be said that the installation at Paddington is the first effort that has been made in England to give a continuous supply of the electric light on a very large scale analogous to that of the rival illuminant gas. In most other installations electricity has been merely an accessory to gas. Here, however, it is intended that the electric light should entirely supersede gas, and the Great Western Company's gas works, from which they supplied their own light previous to the installation, will, it is expected, be closed in a very short time. In places like the "Colonies," for example, although there is a great illuminating power required, the conditions under which it is supplied in no way approximate to the necessities of a house to house supply, as is the case in the installation we are now describing, for the simple reason that there are practically in the former no switches to bring the light under proper control. At Paddington, on the contrary, the lamps all over the extensive district embraced by the installation are entirely under the immediate power of the users, and are turned on and off at will just as gas, and this, too, without the necessity of communicating with the engine house. This is mani-

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festly an advantage which will in the future add to the popularity of the electric light. Suppose, for example, that on some bright day in a given district only 50 or 60 lamps were burning at a given time, and the sky became suddenly overcast to an extent necessitating the use of artificial light—an experience with which dwellers in the metropolis are unhappily too frequently familiar in the winter and spring months—as many lamps as might be required could be turned on in a few minutes by the system adopted at Paddington without in the least injuriously affecting the rest of the installation.

The dynamo room is somewhat nearer the Paddington end of the district than the Westbourne Park end. At one end of the dynamo room is a raised platform, carrying a large and prominent switch board, and a number of Gordon's multiple main regulators, one of which is shown in Fig. 1. The current is generated by the Gordon machine, similar, but larger than the experimental dynamo described and illustrated in *The Electrician*, Vol. IX., pp. 595-6-7-8-9. Figs. 2 and 3, taken from photographs of the dynamo room before the machines were encased in their wooden houses, will, however, give a very good idea of the external appearance of these brobdignagian machines. Three of these dynamos are used, each weighing 45 tons. The sole plates are 18ft. long, and the revolving magnet-wheels are 9ft. 8in. in diameter, and weigh 22 tons each. They run at a uniform speed of 146 revolutions per minute. The dynamos are of the alternating current type, wound to give an E.M.F. of 150 volts. The field-magnets are excited by three Crompton direct-current machines, each of the latter driven by a Willans engine, while each of the former is driven direct by compound tandem engines by Rennie.

The exciting machines are of the Crompton type, and they are what are usually called slow speed machines. They are driven direct by high speed Willans engines, running at about 450 to 500 revolutions per minute. The output of the machines is about 25,000 watts, the E.M.F varied as desired between 110 and 130 volts. The armatures consist of copper bars, and the general appearance of the sets is similar to those used for lighting Old London at the Inventions Exhibition last year. (Fig. 4.)

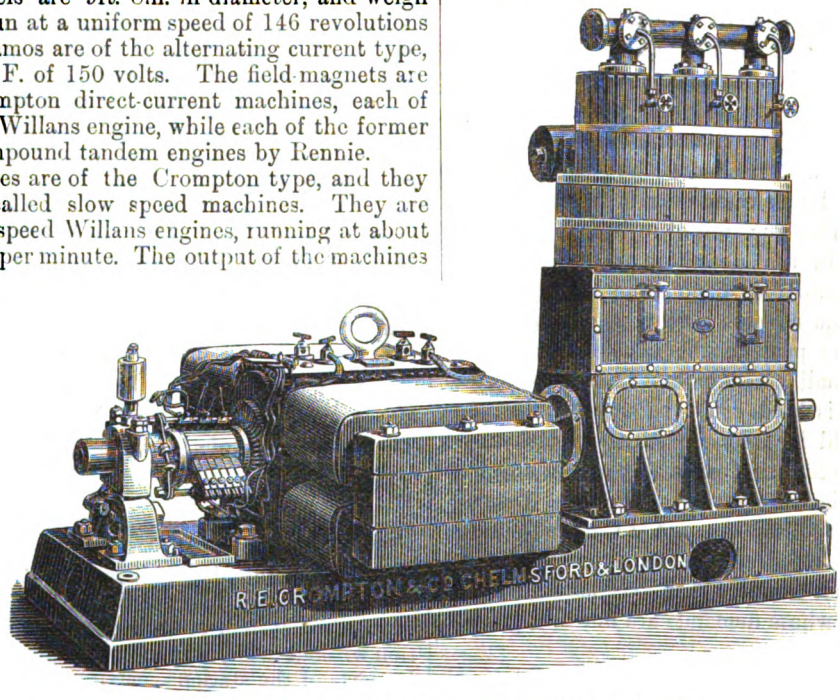

Fig. 4.—Crompton Dynamo, driven by Willans Engine.

The Rennie engines are of the vertical inverted cylinder type, each engine having two low-pressure cylinders and two high-pressure cylinders on the top of them, and each engine is capable of indicating 600 horse-power. The two high-pressure cylinders are each 14in. diameter, the low-pressure 23in. diameter, and the engines have a stroke of 1ft. 6in. The crank shaft is 8in. diameter in the bearings.

Each dynamo is provided with 28 field magnets carried on a revolving wheel. The core of each magnet is cylindrical, 3ft. long and 6in. in diameter. It passes through a disc and protrudes at each side, and has two coils of wire slipped on at the sides. The coils, which weigh 160lbs. each, are kept in their places by the pole plates secured to the ends of the magnets. The central disc is built up of segments of boiler plate riveted together with butt strips, having in the middle an armour plate ring, rolled at the works of Messrs. Cammell and Co. They are steadied, on the principle of a bicycle wheel, by two boiler plate cones, which are kept apart from them by massive iron castings flat at one end and conical at the other. The dynamo shafts are 8in. in diameter, and are run in white metal bearings, the exciting current being taken in by two brushes, which press on insulated brass contact rings. The fixed coils are wedge-shaped, and are each capable of generating about 5 horse-power of electricity. The wires from the fixed coils pass from the dynamo pits under the floor through safety fuses, being separately connected to massive brass bars on the wall. From these bars heavy cables are led to the distributing apparatus in the gallery. In this connection it may be observed that the speed of the exciting machine is regulated by a worm wheel on the stop valve, worked by a rod communicating with the large engine, the dynamo of which is connected with that particular exciter. It may also be mentioned that the exciters are interchangeable—that is to say, that any one of them can be connected to any dynamo when a corresponding change is made on the handgear for driving. Pairs of voltmeters are conveniently placed above each machine, where the engineer may see them, thus enabling him at any moment to control the speed of the exciter in accordance with the indications registered on the voltmeters. A meter is placed in circuit with each exciter, and a glance at it at once shows what the engines are doing without the trouble of taking a diagram. The current of the large machines is measured by an electro-dynamometer inserted in the circuit of one coil of the armature, its readings being afterwards multiplied by the number of coils in the machine. On bright days, when not more than 150 lamps are required, two of the exciters are connected in series and are joined direct to the mains, and the big machines are not run. In that case the current passes through an ordinary ammeter provided with a short circuit.

A very ingenious arrangement has been devised in order to perform the double function of reducing the noise produced by the dynamos and at the same time of ventilating the building in which they are worked. This has been satisfactorily accomplished by incasing the dynamos in a structure of double wood and felt casings (Fig. 5), with double glass windows, made in such a way that the dynamos act as their own fans, withdrawing the air, and with it the noise, from the room, and afterwards expelling the air through wire gauze screens, and discharging it on the railway line away from the houses. Thus a circulating current of fresh air is continually kept up in the chamber, maintaining in it a cool, equable temperature, an appreciable advantage to both the workmen and machinery. There are three engines employed for driving the dynamos, as we have said, and the particular type has been

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adopted with the object of getting over the difficulty of the unequal straining of the cranks which usually results from great differences of load when the engines are running at constant speed, and when the cylinders are placed side by side in the ordinary manner. After many experiments it was found most convenient and serviceable to use the old-fashioned Porter governor for the main engine, and hitherto its working has been found all that could be desired.

Upon the platform in the dynamo room, access to which is obtained by the stairs as shown in the illustration, the most prominent object is the large switch-board. This switch-board is of slate, and is 18ft. long and 8ft. high. Here any dynamo can be connected to either or both circuits, or an exciter or exciters can be connected direct to the circuits. One dynamo can be exchanged for another without interrupting the light, or any particular district can be disconnected for testing.

As we have said, by means of the switch-board one machine can be exchanged for another instantly, without causing a perceptible flicker in the light. This is effected when required by starting the spare machine at speed on open circuit, and working its exciter up till the current is the same as that of the machine which it is intended to replace. When this is done two men, working simultaneously, turn the switches over on the big board, and transfer the load from one machine to the other. The switches consist of massive bundles of copper strip about an inch square, and are curved in an eccentric manner, so as to jam home and make a good contact. Behind the switch-board is the divided main apparatus. The feeding centres are like large cupboards, and each is placed in a central

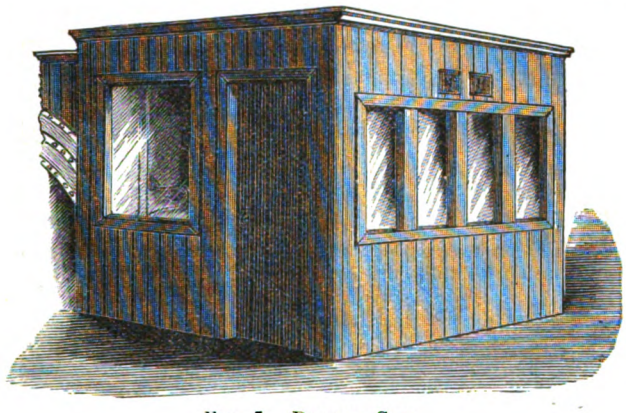

Fig. 5.—Dynamo Case.

part of its district, and is provided with a switch-board, from which the current is distributed to the different portions of the neighbourhood in which it is situated. These centres are all in telephonic communication with the gallery of the dynamo room. This is essential for testing purposes, because where there are a number of wires they have to be disconnected one by one simultaneously at two ends.

Fig. 1 shows the divided main apparatus, which is considered the most important part of the system, for by its use the quantity of copper required in the feeding mains is reduced to one-tenth of that used in the ordinary method. The principle of it is as follows :—In any feeding main the electric pressure at the far end is less than that of the dynamos. The fall of pressure is greatest when all the lamps that the main has to carry are on. If the main is thick and expensive this maximum fall is small, if thin and cheap it is great. When only a few lamps are on the fall is very small. Thus, as lamps are turned on and off there is in an ordinary main a variation practically equal to the fall. As only a variation of not more than 2 per cent. can be allowed, very thick mains have to be used on the ordinary system, so that the fall may not be more than 2 per cent.

The object of the divided main system is to allow a fall of 20 per cent. to be used. For this purpose the feeding main consists of a bundle of wires, as shown at A A (Fig. 1), connected into one at each distant feeding centre. There are five of these distant centres in the district, and they are supplied by twelve feeding mains. Contact apparatus worked by wheels in the gallery allows the component wires of each feeding main to be disconnected one by one. As the wheels are turned round more or less of the component wires are used to form the main cable. Fine wires come back from each feeding centre to the gallery and actuate voltmeters and pilot lamps so that the exact brightness of the light in every part of the district can be seen in the gallery. Suppose, now, a certain number of lamps are switched off in, say, the hotel, its pilot in the gallery brightens a little and calls the attention of the attendant to the voltmeter. He then moves the contact wheel, and, cutting out a segment of the main, reduces its total section, and so increases its resistance and brings back the pressure to its normal value.

To sum up, the thickness of an ordinary main is constant, and, unless it is very large, the variations of current caused by turning lamps on and off cause variations of electric pressure. In the divided main the section is variable, and is kept always proportional to the current the main has to carry, and so the electric pressure is kept constant with a main of one-tenth of the section required for the ordinary system.

A double system of mains is laid throughout (not twice the necessary quantity of wire, but instead of one main of a certain section two of half that section), and in every room, building, yard, &c., half the lights are on one circuit and half on another, and these two circuits are worked by different machines, so that in case of either system breaking down no single room would be left in darkness. In some of the bed rooms of the hotel, where only one lamp is paid for, two are erected on different circuits, and a switch is provided so that either can be lighted at the desire of the inmate, but not both at once.

The pressures in use at Paddington are: "Dynamo centre," *i.e.*, district near the engine house, 150 volts (for this part the divided main is not used); passenger and goods stations and hotel, 120 volts; locomotive station and Westbourne Park, 100 volts. Different lamps are, of course, used in the different districts.

An important provision has been made for the localisation of faults in the system. When an accident happens to a submarine cable it is sufficient, as a rule, to localise the interruption approximately, that is to say, that the cable may be grappled from the repairing ship at a point a hundred yards or so from the indicated position of the fault without causing any serious inconvenience. But in underground mains it is necessary to ascertain the position of any defect within a few yards, because it is obvious that an error in this respect would mean so much expensive excavation. Special arrangements had therefore to be made to meet such a contingency, and they have been entirely successful. In the matter of trimming the arc lamps a great number of special contrivances had also to be devised, as may readily be inferred from the fact that some of these lamps are supported on posts about 45ft. in height, whilst others are suspended from the roofs of the different buildings, which are constructed with girders of varying shapes and dimensions, each requiring a method peculiar to itself of lowering the lamps for the purpose of being trimmed. As a proof of the great trouble which this apparently simple matter has caused the engineers, it may be remarked that between twenty and thirty different patterns of pulleys had to be designed for the purpose.

Fig. 6, the (home district) dynamo-feeding centre switch-board. The different plugs communicate with the various corridors, platforms, &c., by means of wires. Each has its own fuse, which can be disconnected, so as instantly to localise any fault. There is also a means of measuring the current taken at any moment at any corridor, &c., or any pair of arc lamps. This is done by inserting two large plugs connected to the electro-dynanometer in holes, one on each side of the contact plug. The latter is then removed, and it passes through the dynanometer. The plug boards consist of a central brass block, to which the mains from the big switch-board of the home centre or the end of the divided main in the case of the distance centres are connected. Pairs of small blocks joined to each other by a safety fuse are fixed so that they can be connected to the central block of plugs. Wires from these smaller plugs lead to the different corridors, &c.

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Captain Cardew's voltmeters are used throughout, but with considerable modifications in point of structure. Pilot lamps are placed beside each meter in case of its breaking down. Immediately under the staircase leading to the gallery where the switches and distributing plant are situated, the mains from the dynamo terminals are conducted up through a covered way, being thus entirely concealed from view. All the voltmeters are reset by a standard every morning. From the gallery a telegraph wire communicates with the main engine, by means of which the light can be raised or lowered if required.

It is intended shortly to light all the signals about the station. In order that this may be safely done two lamps are placed in each signal lantern, one on one dynamo and one on the other. By means of a switch in the signalman's cabin both lamps can be extinguished, or either can be lighted at will, but not both. If from any cause a lamp filament or wire broke, or from any other accident the lamp went out, an alarm bell at once rings in the signalman's cabin, and a disc shows which of them is wrong. The bell goes on ringing until the signalman puts over the switch, and lights the spare lamp. At the same time another bell rings at the dynamo room, and the disc comes up to show at which cabin the lamp is defective. This bell goes on ringing until the lampman arrives at the signal cabin, so that the officer in charge can tell how long this individual has been on the road. If a lamp breaks, the light is out only for a second, and the lantern depends on one lamp instead of two for a few minutes. The apparatus used consists of two little solenoids (Fig. 7), one in circuit with each of the lamps. If either is pulled down while the lamp is burning, the bell circuit is broken. But if both lamps are out at once, both cores fly up, and the bell circuit is completed; then the alarm bell rings, and the disc comes up in the way usual with electric bell arrangements. When, however, the bell is switched out purposely by the signalman the bell does not ring, as the switch, which extinguishes the light, is so arranged that before doing so it breaks the bell circuit. A full-sized model of this device is at work in the engine room, and all the cabins and signals are wired and fitted with the apparatus. It is thought advisable, however, not to connect it until the plant has been at work for a few weeks longer.

Fig. 8 shows a domestic meter. The Gordon meter is not used at Paddington, as the light there is supplied at so much per annum, and not by meter. But a single meter is put up for experiment and measures the light supplied in the dynamo room and the different offices. It consists of solenoids which pull cores into them against a counter weight, according to the number of lamps at work. This, as they are drawn in, causes a snail wheel to revolve, and increases the distance from the upper edge of that wheel to a point vertically over it. A train of clockwork causes an arm to fall every quarter of an hour from a fixed point to the then position of the upper edge of the snail wheel. If no lights are on it falls no distance. If many lights are on it falls a distance proportionate to the number. As the arm rises again it engages a train of counting wheels. Thus the meter consists of a free galvanometer and apparatus which searches every quarter of an hour for the position of the galvanometer needle and adds together the lengths of all the journeys which it makes in those searches in, say, three months. The clockwork is not wound up, but is driven by a tuning fork, actuated by a fine wire magnet into which the alternating current is admitted. It runs at a uniform speed whether few or many lamps are on; but when no lamps are on, the balance weight of the cores lifts a contact spring and stops the clockwork, so as to save wear and tear.

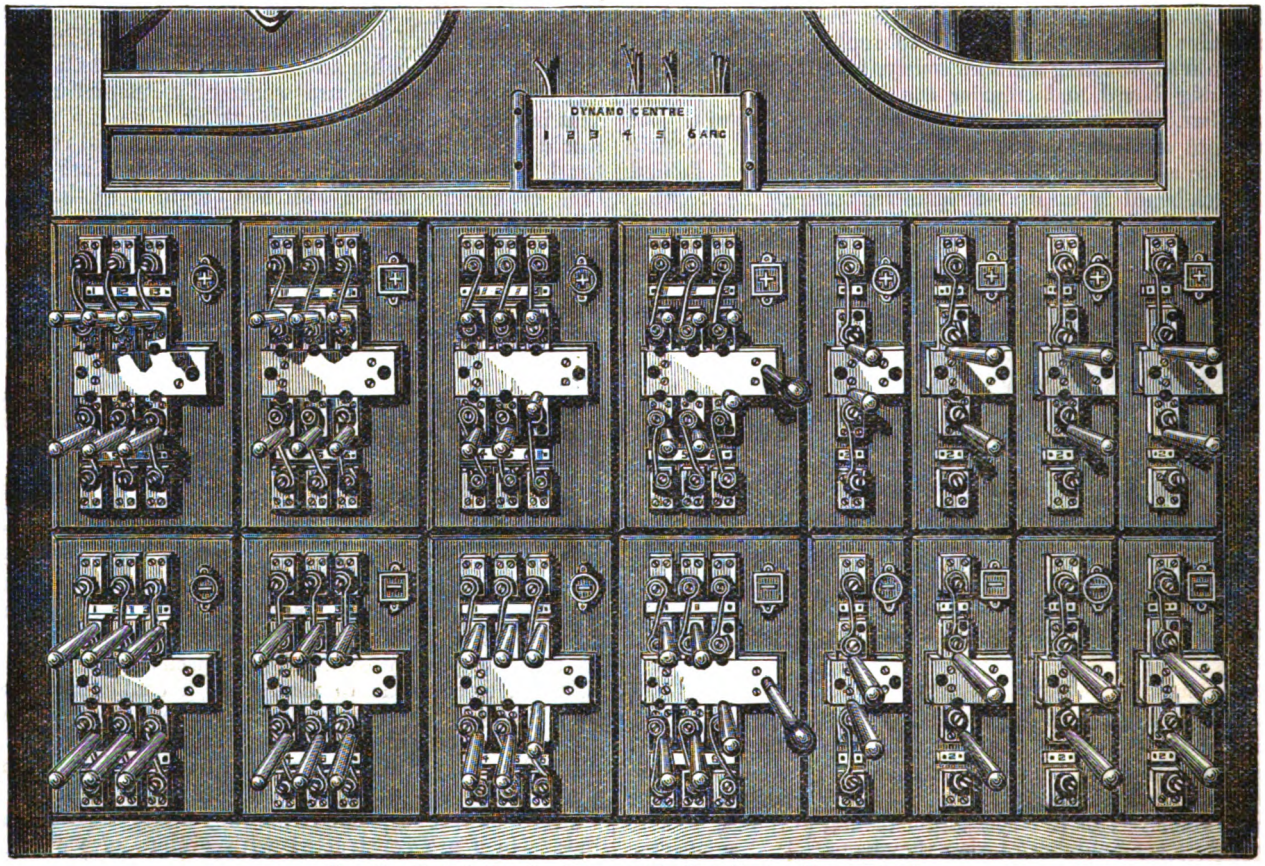

Fig. 6.—Switch Board. Dynamo-Feeding Centre, Home District.

Steam is supplied to the engines by two rows of pipes connected with nine large boilers (Fig. 9), not more than five or six of which are in use at one time, so that in case of a pipe bursting, one line of pipe can be shut off without interrupting the supply. Some idea of the elaborate nature of the arrangments may be gathered from the fact that there are forty-two stop valves in use, independently of small cocks. The feed water is heated by a portion of the waste steam, which is turned into a receiver where it meets a spray of water from the tank, heating it as it falls. To equalise the pressure, the pipe is connected to a hydraulic accumulator weighted at 180lb. to the square inch. As the boiler pressure is 120lb. this gives a difference of 60lb. to force the water into the boilers. The speed of the feed pump is regulated

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by a throttle valve connected by a link to the hydraulic accumulator, and when the latter is at the top of its travel it stops the pump.

The water is supplied from three independent sources, *i.e.*, the Grand Junction Company's mains, the Canal Company's supply, and the hydraulic accumulators used to work the cranes and turntables in the station. Water can be introduced into the boilers by three methods, *i.e.*, (1) cold, by the hydraulic pressure used for working the cranes, &c., in the station; (2) cold, by injectors; (3) hot, by the steam pump and ram just described. The first two methods are only used in case the hot-water pump breaks down. Welsh coal of a special quality is used, and the furnaces are specially constructed, so that no smoke whatever is produced. The invisible products of combustion and the waste steam are discharged through two chimneys, 90ft. high, whose tops are far above the chimney pots of the neighbouring houses.

FIG. 10.—Chandelier in Board Room.

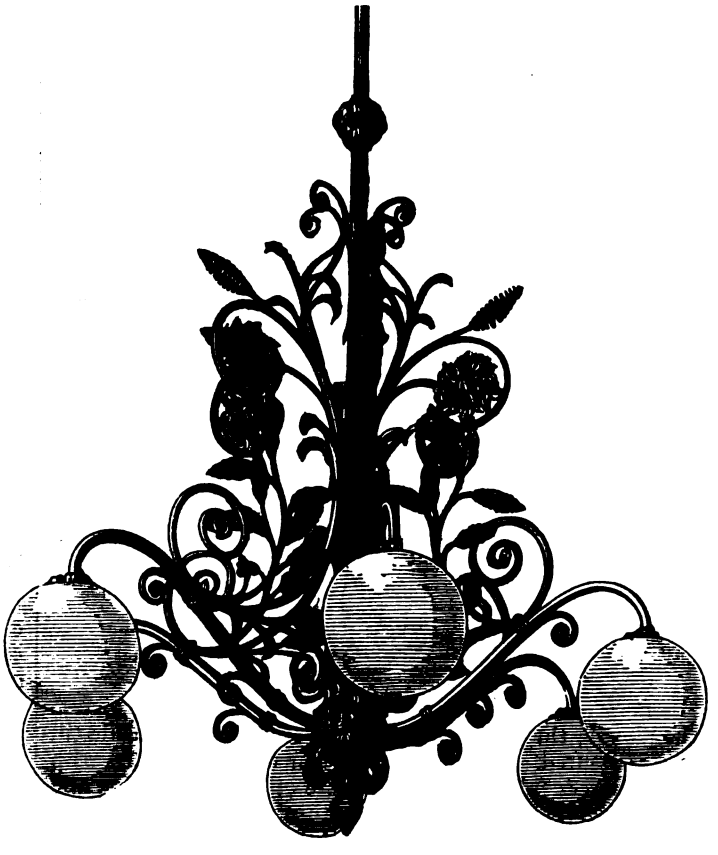

FIG. 11.—Chandelier in Sir D. Gooch's Room.

The contract with the Great Western Railway Company provides that every lamp should have a separate switch, so that it can be turned on and off independently. The incandescent lamps are entirely under the control of the users, and out of the control of the contractors, exactly as in the case of gas. Th current is always on day and night, except for three hours in the daytime on Sunday, when it is interrupted for testing purposes. The contract supply was commenced on April 21st, and has continued without hitch or difficulty up to the present time.

Figs. 10 and 11 illustrate some of the chandeliers, designed and manufactured by Messrs. Cooper, of Great Pulteney-street, these being placed in the Board room and Sir D. Gooch's room at the Paddington Station. The arc lamps are Crompton-Crabb DD type, specially adapted for alternating currents. Through the large lamps facing Praed-street a current of 40 amperes is passed, thus making them the largest lamps in constant use.

The Crompton-Crabb lamps are notable for their simplicity in construction, and consequent non-liability to get out of order. They can be made for use with continuous or alternating currents, and for running parallel with incandescent lights. It is found that the use of alternate currents with these arc lamps has a tendency to keep the light extremely steady. A lamp mast is shown in Fig. 12. The incandescent lamps are Swan lamps.

In the case of an accident occurring on the railway, such as an engine running off the line, a pair of arc lamps supported on tressels are always in readiness outside the engine house, together with a handbarrow, on which is a drum containing 400 yards of wire. These lamps can be instantly carried to any point of the district. The wire may then be unwound and connected to the nearest arc lamp post or feeding centre, when the light can be at once put on.

The arcs are two in series, each pair being in parallel with the incandescent lamps, and are fed from the same mains. In series with each pair of arc lamps is a resistance coil of peculiar shape, calculated from a formula of Prof. Clerk-Maxwell's to have the maximum possible self-induction. These resistances are so adjusted that when the lamps are right they have very little effect, but directly the carbons run together the resistance increases greatly and chokes any rush of current. Tin safety fuses are used throughout to guard against any possible fire-risk. The current passes through nine of them in its way from the dynamo to any lamp.

Some idea of the magnitude of the work may be formed from the following miscellaneous figures:—500 miles of wire

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have been used. The wires in the offices and corridors are enclosed in wood casing. Of this 12 miles have been used. The casing is fixed to the walls by 94,000 screws. The underground mains are contained in thin iron troughs, like rain-water gutters with lids; of these 140 tons have been buried. About 25,000 joints have been made; 20,000 labels have been used for ends of wire; 2 tons of terminals and connectors have been used; 260 yards of massive masonry (in a number of short lengths) have been built under the lines to prevent the weight of the trains crushing the mains where they cross under the lines.

The incandescent lamps are all in parallel.

We have said enough in the description of this installation to show the great care that has been taken to obtain success in every detail. Mr. Gordon must be congratulated upon the success attained. First known to the world as an earnest student and a successful writer, he has now shown that he can carry out his ideas in practice. With regard to the Telegraph Construction and Maintenance Company, success is only what we expect in whatever they undertake. Having put their hands

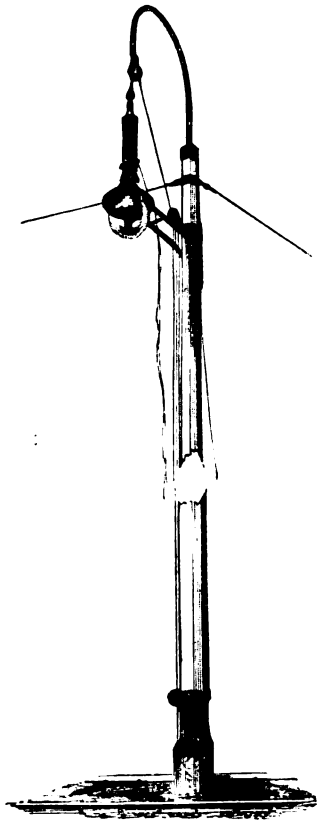

Fig. 12.—Arc Lamp Mast.

to the plough, they neither look backward nor turn aside till success is assured. We never hear their name associated with failure. Successful in the manufacture of cables, in laying and in picking up cables, they have now turned their attention to an industry which bids fair to rival their cable work in extent, and we can but express the hope that their success in the later venture may be far greater than in anything they have hitherto undertaken. The credit of the Paddington work must be given to Mr. Gordon, who has, we believe, had the complete management of the work, and has been ably assisted by Mr. F. Bailey, M.S.T.E., the resident engineer. In conclusion, there is one remark we should like to make as to the success in getting rid of noise at the central station. It is almost impossible to distinguish any noise, even in the next room to the dynamos when they are running full speed. The effect of enclosing the machines is wonderful, and one of the most satisfactory items of detail.

Telegraph Stores Wanted.—The Directors of the North-Eastern Railway Company invite tenders for Telegraph Apparatus and Telegraph Wire and Line Stores. Further particulars will be found in our advertisement columns.

TELEGRAPHING WITH TRAINS.

The Phelpsian system of telegraphy with trains in motion is based on the electro-dynamical induction between a cable placed between the rails and a wire frame of large dimensions in the carriage.

Another method lately brought forward by Edison and Gilliland depends on statical induction. Fig. 1 represents the arrangement in the station, Fig. 2 that in the carriage. The metal roof of the carriage is united with the reversing key S. If the key is to the left it closes the circuit through the telephone T, which is connected to earth by connection with the wheels. Thus all is ready for receiving a message. If S is to the right, it closes the circuit through the secondary coil of an induction apparatus G. The primary coil is in circuit with an automatic contact-breaker or interrupter which may be regarded as a modification of the well-known Wagner's hammer. A spring, R, which vibrates pretty quickly, is kept going by a battery, B (the upper one in the figure), and alternately opens and closes the primary circuit, in which is the other battery. In the primary circuit there is an ordinary Morse key, K, so that the current can only pass in it when this is closed.

Suppose S to the right and K closed, then the primary coil is traversed by an intermittent current, which would engender

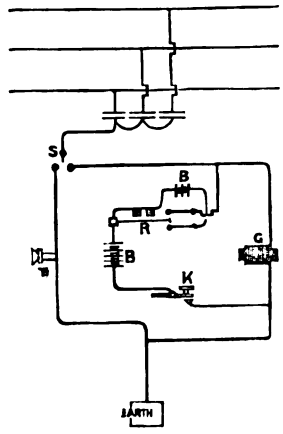

Fig. 1.

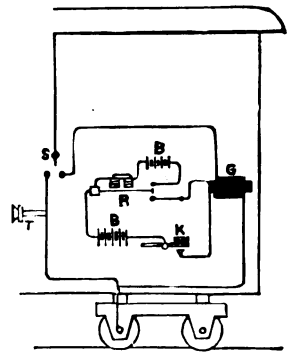

Fig. 2.

induced currents round the secondary coil if its circuit were closed. Instead of this being the case one pole of the coil is connected with the metal roof of the carriage, which thus receives an alternately positive and negative charge. The charges of the roof induce charges of opposite sign in the railway telegraph wires in the neighbourhood. The wires are in connection, as Fig. 1 shows, with one set of coatings of the condensers, whilst the other coatings are connected with an apparatus at the station like the one in the carriage. If one apparatus signals, a musical note is heard in the telephone of the other, which is interrupted by the Morse key, just as in Morse telegraphy. Thus a telegraphic understanding is rendered possible. In place of the condensers Edison has also employed induction coils.

The ordinary telegraphic currents which were passing in the line during the experiments were not prejudicial to the communication, which fact may be ascribed to the circumstance that these produce less strong charges, and besides subside less suddenly.—*Centralblatt für Electrotecknik.*

THE COLONIAL AND INDIAN EXHIBITION.

The arrangements of the Conference Committee, of which the Duke of Manchester is chairman, are now fairly complete. The meetings are open to all visitors to the Exhibition. The following papers will be read:—"Imperial Federation," by Mr. F. B. Labilliere; "Our Colonial Wool Supplies," by Mr. P. L. Simmonds; "Importation of Grain and Bread-Stuffs from the Colonies and India," by Mr. S. B. L. Druce; "South Africa as a Field for the Emigration of the Industrial Classes," by Mr. Arnold White; "The System of Land Transfer adopted by the Colonies," by Mr. J. D. Wood; "The Mineral Resources of India, by Prof. Valentine Ball, F.R.S.; "British-Grown Teas," by Mr. L. J. Shand; "Indian Carpets," by Mr. Vincent Robinson; "Emigration to the Colonies," by Mr. F. Young. The papers will be followed by discussion.

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RELATION OF "TRANSFER-RESISTANCE" TO THE MOLECULAR WEIGHT AND CHEMICAL COMPOSITION OF ELECTROLYTES.*

BY G. GORE, LL.D., F.R.S.

In the full paper the author first describes the method he employed for measuring the "resistance," and then gives the numerical results of the measurements in a series of tables.

He took a number of groups of chemically related acids and salts of considerable degrees of purity, all of them in the proportions of their chemical equivalent weights, and dissolved in equal and sufficient quantities of distilled water to form quite dilute solutions. The number of solutions was about seventy, and included those of hydriodic, hydrobromic, hydrochloric, hydrofluoric, nitric, and sulphuric acids; the iodides, bromides, chlorides, fluorides, hydrates, carbonates, nitrates, and sulphates of ammonium, cæsium, rubidium, potassium, sodium, and lithium; the chlorides, hydrates, and nitrates of basium, strontium, and calcium; and a series of stronger solutions, of equivalent strength to each other, of the chlorides of hydrogen, ammonium, rubidium, potassium, sodium, lithium, basium, strontium, and calcium. A series of similar liquids to those of one of the groups of acids, of equal (not of equivalent) strength to each other, was also included.

As electrodes he employed pairs of plates of zinc, cadmium, lead, tin, iron, nickel, copper, silver, gold, palladium, and platinum; and separate ones formed of small bars of iridium.

He took each group of solutions, and measured in each liquid separately, at atmospheric temperature, the "total resistance" at the two electrodes, and the separate "resistances" at the anode and cathode respectively with each metal, and thus obtained about seventy different tables, each containing about thirty-six measurements, including the amounts of "total," "anode," and "cathode resistance" of each metal, and the "averages" of these for all the metals.

By comparing the numbers thus obtained, and by general logical analysis of the whole of the results, he has arrived at various conclusions, of which the following are the most important:—The phenomenon of "transfer-resistance" appears to be *a new physical relation of the atomic-weights*, attended by inseparable electrolytic and other concomitants (one of which is liberation of heat, *Phil. Mag.*, 1886, Vol. XXI., p. 130). In the chemical groups of substances examined, *it varied inversely as the atomic-weights of the constituents, both electro-positive and electro-negative, of the electrolyte, independently of all other circumstances*; and in consequence of being largely diminished by corrosion of the electrodes it appeared to be intimately related to "surface-tension." He suggests that such corrosion may be a consequence, and not the cause, of small "transfer-resistance." The strongest evidence of the existence of the above general law was obtained with liquids and electrodes with which there was the least corrosion and the least formation of undissolved films; those liquids were dilute alkali-chlorides, with electrodes of platinum.

This research is an extension of a former one on "Transfer-resistance in Electrolytic and Voltaic Cells," communicated to the Royal Society, March 2, 1885. Further evidence on the same subject has been published by the author in the *Philosophical Magazine*, 1886, Vol. XXI., pp. 130, 145, 249.

* Abstract of Paper read before the Royal Society, May 20, 1886.

COMPANIES' MEETINGS & REPORTS.

The West India and Panama Telegraph Company (Limited).

The eighteenth ordinary general meeting of the members of the West India and Panama Telegraph Company (Limited) was held at the City Terminus Hotel, Cannon-street, on the 27th inst., under the presidency of Mr. C. W. Earle.

The SECRETARY (Mr. R. T. Brown) read the notice convening the meeting, and the report of the Directors was taken as read.

The CHAIRMAN: Gentlemen, we meet under the somewhat depressing influence of declining traffics. Whether a railway, a steamship, or a telegraph company, a decline in traffics, I think, has been painfully brought before the notice of everyone interested in undertakings of a similar sort. In the present year, it may be noted, if the traffic receipts that we had two years ago—in 1883—had continued what they were then, we should have been in a position, putting the same amount as we do now to the reserve fund, to pay a dividend of 5s. a share extra this year on the preference shares. The whole difference is occasioned by the depression of trade, which is general, and particularly felt in the West Indies. Upon the details of the accounts I have very little to remark. I think they are perfectly featureless as far as expenditure goes, and they are very much on the same lines as they invariably are with us. The balance that we have to deal with, of £14,817, is practically the same as it was at this time last year, although the revenue has fallen off; and the reason of its being the same is to be accounted for by the chance during the six months of our having had to bring the ships home to fetch out new cable, while the expense of the voyage is charged to cable account. They are earning freight which otherwise we should have had to pay for to the carriers of that cable, and the saving effected in that way enables us to show a balance of about the same amount as we did this time twelve months. In the present condition of affairs there is nothing for us to do but to maintain the cables, so as to enable us to take advantage of any improvement in trade that may come about; and in connection with that consideration it is satisfactory to be able to report as we do in the third paragraph that the original Cuba-Jamaica cable which has been interrupted and inoperative for seven years now, has been repaired with a very much smaller expenditure of cable than I anticipated the last time I met you. The interruption of this cable was in the northern half of the section, and in very deep water, and as I told the last meeting, although we could get hold of the cable, so great was the depth that it was impossible to bring it up to the surface of the water. It was not in a condition to bear its own strain in lifting it to a very great height. The ship "Grappler" came home in order to take out the cargo of cable, 250 knots, and we then had an opportunity of discussing the question with the captain who had been engaged in these repairs. We left him a good deal of latitude as to what his operations would be, but we sketched out, of course, what we thought would yield us the greatest success, and the course that would yield us the greatest success means the saving of the greatest amount of the old cable. He went to where he found 1,300 fathoms of water, which is a good depth, and picked up the cable there, slipped in new cable of 46 knots, and ran to Santiago. There then remained about 25 knots to put in at the Jamaica end, and that was a total expenditure of 71 knots, whereas I thought at one time that we should have to relay the whole of the cable. The cable is put through, and is working very satisfactorily now. The other cable that has given us so much difficulty—a cable very much in similar circumstances to the one I have just spoken about—the original Jamaica-Porto Rico cable failed in November last. At the last meeting we were all rejoicing at the very successful repair that we had made on that cable. It had been for a long time interrupted, and it gave us great difficulty; but in 2,400 fathoms of water the cable failed last November—not in the new cable that we had put in, but in the original cable that had been lying there for fifteen years. It is impossible to get hold of the cable at that depth, and if we could get hold of it we could not get it up to the surface of the water, and we must go to a considerable distance on either side of it until we can grapple it with success, and then we shall have to join the two lengths of cable, and put it through again. The third cable—the Trinidad-Demerara section—has been again interrupted. It has been interrupted twelve times since 1879. It lies in shallow water; but it appears that there is something in the composition of the mud on that coast that is poured from the Rivers Essequibo and Oronoco that has a deleterious effect on the iron wires of the cable. That cable has been there for 15 years, and it seems to be going the way of all flesh. We have, therefore, made some proposals to the Government of British Guiana for replacing that cable with a new one of some improved construction to protect the iron wires from the effects of the mud in which that cable lies. We have not yet received any decision from the Government there, and it would not be advisable to discuss the proposals at present. But I hope we shall be able to lay a new cable there without, at any rate, very great sacrifice of revenue to the Company. The concluding part of this report is perhaps the most important one that I have to touch upon to-day. Of all the companies I ever knew there is none whose position so constantly fulfils the idea of being between the devil and the deep sea as the West India and Panama Company. I have given you instances of the disadvantages which the deep sea on the ground where we work causes us. The other unpleasant neighbour assumes various forms. Sometimes it is a promoter with a wild scheme to connect islands where there is no traffic. On that matter we have had some revelations lately. I daresay you saw a case in the papers where some gentlemen had proposed a cable in those regions, and the preliminary proceedings in connection with it were the cause of an action in the courts of law. However, it remains with the public whether these things are subscribed for. The promoters get a profit and leave the public to fish for themselves, after they have made the cable, in very deep water and with very small traffic. I think, after our experience in that part of the world, where there is very small business, and where the water is very inimical to the conditions of telegraphic working, it is not at all encouraging to subscriptions being got from the public. But the new enemy we have is our own Government now. The history of this scheme, that was made the subject of an advertisement, as stated in our report, is as follows:—In the year 1882 there was a telegraph conference at Barbadoes. Representatives from the various West India colonies met there and decided that it would be expedient for them to have a direct line of communication to Halifax, Nova Scotia. They thought by doing that they would be able to get cheaper rates for their messages to England. I do not know how they expected that, because if the enterprise were conducted on commercial principles, there is no doubt that a cable all the way along the coast of America merely carrying the West India traffic, which is very small, would not be worked at so low a tariff as the land lines of America, which are supported by the

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traffic of the population through which those lines pass. They thought that it would be a nice thing to have a direct line, probably at the expense of the English Government. The matter was put before the Government, and the late Mr. Fawcett reportedly adversely upon it, and very fairly said that the West India and Panama Company would have very just cause of complaint if the Government subsidised a new line. He was then Postmaster-General. The next time we heard of this was that the same scheme was advised by a Royal Commission that was sent out to investigate West Indian finances and West Indian affairs in 1884, and that Royal Commission advocated this scheme. Those who were shareholders at that time may remember that we appended a notice about it in our report. The report of the Royal Commission came into our hands after our report was printed in 1884, and we appended a notice of what they said, and our objections to the scheme. We heard nothing more of it then, until this advertisement appeared last November. It seemed curious that the Government of the day, that was so much interested and so alarmed at the depression of trade and industry at the time, should with a light heart have advised a scheme by which about two millions of English capital were to be almost ruined, because I conclude that the Cuba Company would be very great sufferers as well as ourselves if this line were established. It seems curious that a Government which went out of their way rather in appointing a commission to inquire into that subject should at the same time have adopted a scheme that would so plainly depress a very large amount of capital, and also impair very much the power of this Company to maintain the West Indian connections, which extend all down the Antilles. If our revenue is to be taken from us, how is our Company to keep up the connections with Demerara, Barbadoes, and other important colonies? We have laid our views and objections before the Government, and we have heard nothing of the matter since. I hope the subject may be allowed to drop; but we never feel safe, as one does not know what Parliament may advise. I trust, if such a scheme does come forward, the public will be very careful how they subscribe to it. The water through which the cable will have to pass is deeper than any we have to deal with. It was referred to by the "Challenger" expedition as the deepest in the world. They could hardly get bottom with all their appliances for sounding. In making these remarks about this particular line, I am not saying anything about the expediency of a cable from Halifax to Bermuda, where there is no cable. Bermuda is a great naval station, and no doubt it is a praiseworthy thing for the Government to try and establish telegraphic communication with such an important spot as that. But as to Jamaica, there are three cables already there. No doubt the reason for proposing this step is the idea of having solely British connections with their naval stations and garrisons. But when we have such stations as Aden, Gibraltar, Malta, India itself, and our Australian colonies, all dependent to some extent on foreign communications, it seems strange that they should go out of their way to deal with this matter in the manner I have referred to. It seems rather strange to tell the English taxpayers to promote a line that will do so much damage to existing British capital. I now move:—"That the Directors' report and accounts to the 31st December, 1885, submitted to this meeting be and the same are hereby received and adopted, and that, as recommended by the Board, a dividend of 6s. a share on account of arrears of dividend on the first preference shares be and the same is hereby declared."

Mr. Wm. Ford seconded the motion.

Mr. W. Griffith said he was sure that the appeal which the Chairman had made to the public was one that commended itself to every well-principled mind. The competition which would inevitably result from the new cable to which reference had been made would be to the disadvantage of the Company without benefiting the Government. Why they should not transmit the messages for the Government he could not see. If the Government were to lay down the new cable the result would be that their system would be ruined; but though the Government might be able to send their messages to Bermuda and Jamaica they would be unable to forward messages to any of the other West India Islands. Looking at the matter commercially the distance from Bermuda to Jamaica was so great, the depth of water was so great, that when an accident occurred they would be unable to send any of their messages, and in that case they would be in a worse state than at present. That any high minded man—such as the nobleman who presided over the late Government—should have condescended to propose to enter into competition with two private companies was almost incredible. Fortunately that party was not in power at present [laughter]. He thought, both on commercial and constitutional grounds, the Government ought to abstain from doing that which would ruin the Company and be of no great advantage to the people at large, but rather the reverse. The Chairman had stated that it was the intention to lay down a new line at the extremity of their system, the Trinidad-Demerara cable having become almost useless. If the Government were to step in and help them in that they would help the Company and the naval service. He trusted that in carrying out that cable the Directors would exercise their usual ability, and consider fully the interests of the shareholders, for it must be remembered that that part of the line was quite at the extremity of the Company's system, and that it did not assist them much in the carrying of messages. It was, as he had said, quite at the end of their system, and, therefore, if British Guiana hoped to derive any benefit from it, it was their duty to come forward and assist the Company in assisting them. They were much indebted to the Directors. With 22 stations to command, and with the constant breaks which they heard of, it could not be very easy to manage such a Company as theirs, and they ought, he thought, to tender their thanks to the Board and to assure them that they would have the shareholders' support in resisting any such unconstitutional proceeding as that of high-handed conduct on the part of the Government to injure a private company.

Mr. William Abbott thought that the last speaker's political zeal had outrun his discretion. He did not think it was the Postmaster-General of the late Government that had desired to inflict such an act of spoliation upon them, but the Postmaster-General of the present Government.

The Chairman: No, it was the last Government.

Mr. William Abbott, continuing, said that that being so he was filled with humiliation, because he had thought the late Government respected the rights of property in a marked degree compared with the present Government.

Mr. Ford observed that it was never a question for the Cabinet. It was merely a question of departmental detail.

Mr. Abbott thought that every meeting of shareholders should express their abhorrence at these constant raids on the rights of property—he did not care whether by the present or the late Government. The first raid was on land, then on shipping, then on railways, ground rents, and consols.

Mr. Ford: And the coinage.

Mr. Abbott: And the coinage. When these things were occurring every day, and meetings were called to denounce such conduct towards the rights of property, it was only proper for shareholders in telegraph companies to be up and doing in the same way. They saw the fearful contest that was now going on in the Atlantic, the messages being carried at 6d. per word, and he did not think the commercial interest could complain. Surely the commercial interests of the West Indian Islands could not complain; they had not suffered as the Company had. As to the idea of laying a line from the West India Islands to Halifax, it was a monstrous absurdity, but it was very proper that a monstrous absurdity should be exposed at a meeting of that kind so as to warn those who might be induced to subscribe to it. There was quite enough suffering in their Company from what they had done for the West India islands, and it was their duty to warn those who might be induced to subscribe further money to an enterprise of this kind that they would do so with the certainty of loss. In looking down the balance-sheet and accounts, he must say that they had treated the revenue account with every care and consideration, and he could not find any fault with any of the charges to its debit. Some said that such such an amount should be reduced, but, considering the difficulties they had had to contend against, and keeping up a large staff of men in an unhealthy climate, he must say that he had looked into the report with perfect satisfaction, though he had at first felt disposed, in the interest of those he represented, to cavil at some of the items.

The resolution was carried unanimously.

On the motion of the Chairman, seconded by Mr. William Andrews, Mr. Henry Holmes was re-elected to his seat at the Board; as was also Mr. Henry Weaver, on the motion of the Chairman, seconded by Mr. Ford.

Mr. Griffith then proposed the re-election of Mr. John George Griffiths as auditor of the Company, observing that that gentleman had served them for a long time. As Mr. Abbott had remarked, everything was clear and open, and it was to the advantage of the Company that Mr. Griffiths should be re-elected.

The motion was seconded and carried unanimously.

Mr. Abbott then proposed a vote of thanks to the Chairman and Directors for their services in the past half year. The Chairman had remarked that it seemed strange that the Government should propose to subsidise a rival line. The Government was said to be economical; and therefore, why did they not give the subsidy to the West India and Panama Company? The administration of the money would be very much more economical, and they would get an efficient service against a doubtful one. He wished to give the Directors a word of admonition, as they would not meet again for six months. British colonists were always greedy.

Mr. J. Newton seconded the motion, which was carried unanimously.

The Chairman: On the part of my colleagues and myself I am very much obliged to you for the cordial vote you have given us. I quite recognise the justice and force of Mr. Abbott's remarks, and I hope they will go further, and that people will see that it is not to their interest and the interest of other capitalists in this country to put their money into wild competing schemes merely for the benefit of promoters and people of that class.

The proceedings then terminated.

Telephone Company of Egypt (Limited).

An extraordinary general meeting of the members of this Company was held on the 25th May, at the offices of the Company, 14, Austinfriars, E.C., General Alexander Fraser, C.B., R.E., presiding.

The Chairman proposed and a Shareholder seconded the following resolutions, which were unanimously carried:—

1. That Article 29 of the Articles of Association of the Company be altered by the addition of the following words:—"Provided that no shares shall be allotted at a discount, or on or subject to any special terms or conditions without the previous consent of a meeting of the Company."

2. That Article 56 be rescinded, and the following be adopted in its place:—"The number of Directors shall never be less than three, or more than seven. The directors may at any time, and from time to time, appoint any other persons to be directors, but so that the total number of the directors shall not be more than seven. The continuing directors may act, notwithstanding any vacancies in their body."

3. That Article 58 be rescinded, and the following be adopted in its place:—"The remuneration of the directors shall not exceed the sum of £800 per annum, but the actual amounts to be paid them shall be settled and determined each year by the shareholders in general meeting for the ensuing year, and such remuneration shall be divisible amongst them as they may themselves determine."

4. That Article 60, Clause (a), be altered by the addition of the following words:—"Provided that the total amount for the time being owing

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shall not, without the previous consent of a general meeting of the Company, exceed £5,000."

To insert the following words in Clause (*c*) of the same Article after "they may":—"With the previous sanction of a general meeting." That Clause (*d*) of the same article be rescinded and the following substituted:—"They may from time to time appoint any one or more of their number Managing Director or Managing Directors, with such share or proportion of the remuneration payable for the time being under Article 58, and for such period as they deem fit." To insert in Clause (*e*) the following words after "grant him":—"Subject to confirmation of a general meeting." To insert in Clause (*f*) after the words "they may":—"Subject to the limitations imposed by paragraph (*a*) of this article" And to add the following words at the end of the same clause:—"And every bill, promissory note, cheque, or other negotiable instrument drawn, made or accepted, shall be signed by two Directors, and countersigned by the secretary or other officer of the Company appointed by the Board." To cancel altogether Clause (*j*) of the same Article (60).

5. That Article (63) be rescinded, and the following be adopted in its place:—"No contract or arrangement entered into by or on behalf of the Company with any company, corporation, or partnership, of or in which any director shall be a member or otherwise interested, shall be avoided, nor shall any director being such member or so interested be liable to account to the Company for any profit realised by any such contract or arrangement by reason only of such director holding such office, or of the fiduciary relation thereby established; but no director shall vote in respect of any such contract or arrangement."

6. To omit from Article 82 the word "cumulative." The clause to read thus:—"First.—To the payment of a preferential dividend at the rate of £7. 10s. per cent. per annum on the capital paid up on the preferred shares."

London Platino-Brazilian Telegraph Company (Limited).

Report of the Directors for the twelve months ended March 31 last to be presented to the eighth ordinary general meeting of the shareholders to be held at the offices of the Company, 50, Old Broad-street, E C., on Monday, May 31st at noon.

The net revenue of the year, after providing for debenture interest and income tax, is £4,087. 18s. 5d., and £1,068. 4s. 11d. is brought in from the preceding year's account, making a total of £5,156. 3s. 4d. to the credit of revenue account. The interim dividend of 1s. per share, paid on the 17th November, 1885, absorbed £1,917. 8s., leaving therefore to be dealt with £3,238. 15s. 4d., from which the Directors propose to appropriate £150 in further reduction of the item of expenses of issue of the 6 per cent. debentures, and £1,917. 8s. in payment of a final dividend of 1s. per share, making, with the interim dividend already paid, a distribution at the rate of 1 per cent. per annum; leaving a balance of £1,171. 7s. 4d. to be carried forward against the amount due by the Uruguay Government. The competition for South American traffic with the cables of the North Atlantic and of the West Coast of America companies has continued during the past year, and has seriously diminished the revenue of the Western and Brazilian Company, in which this Company is so largely interested. The claim of this Company against the Western and Brazilian Company, referred to in previous reports, remains unsettled. The revenue from our land lines shows only a small increase over that of 1884, but from the beginning of the current year there has been considerable improvement in the traffic. The Company's lines are in good working order. According to the Articles of Association, John Pender. Esq., a Director of the Company, retires by rotation, and offers himself for re-election.

West Coast of America Telegraph Company (Limited).

Report of the Directors to be submitted to the ninth ordinary general meeting of the shareholders at the offices of the Company, 50, Old Broad-street, E.C., on Wednesday, the 2nd June at one o'clock p.m.

The accounts for the year ended the 31st December, 1885, show a gross revenue of £45,957. 10s. 10d. against £52,011. 10s. 7d., earned in the previous year. After deducting debenture interest and all other charges, there remains a net balance of profit of £12,890. 12s. 2d., making together with £349. 1s. 3d. brought forward from the previous year £13,239. 13s. 5d. out of which the following dividends have been paid:—

In June, 1885	2s. per share,	£3,000
In January, 1886	3s. ,,	4,500
		£7,500

leaving an available balance of £5,739. 13s. 5d.; of this amount the Board recommend an addition of £5,000 to the reserve fund, which will then amount to £15,000, carrying forward £739. 13s. 5d. The unfortunate war between Chili and Peru, which happily is now at an end, has seriously affected the earnings of the Company, and the general exhaustion caused by that protracted struggle will doubtless be felt for some time to come. However, there appear to be already some signs of improvement in the trade on the West Coast, and with the establishment of a more stable Government in Peru a gradual increase in traffic may be expected. The working expenses of the Company show little variation from those in the previous year. Both cables and the repairing steamer are kept in perfect working order. With great regret the Directors have to announce the loss of the valuable services of their late Chairman, Mr. Robinson Kendal, who died very suddenly on March 13 last. The Board has appointed in his place Mr. Alfred Marshall, formerly partner of the firm of Messrs. Frederick Huth, Grüning, and Co., of Valparaiso and Lima, who has been for many years a resident on the West Coast. The members of the Board retiring by rotation are Mr. Henry Roberts and Mr. Alfred Marshall, both of whom, being eligible, offer themselves for re-election. The auditor, Mr. J. Weise, of Messrs. Turquand, Youngs, and Co., retires, and is eligible for re-election.

BUSINESS NOTICES.—We are asked by the Stanhope Company (Limited) to notify that, under the authority of the Board of Trade, the name of Cordner, Allen and Company (Limited), of 20, Bucklesbury, E.C., has been changed to the Stanhope Company (Limited), by which name the Company will henceforth be known. Mr. W. J. Cordner has retired from the Company, the present Directors being Messrs. James Ashworth, T. M. Collet, and John S. Sawrey.—The business of the Signal Engineering Company is transferred to 26, Red Lion-square, Holborn, where the company carries on the manufacture of telephones and electrical apparatus under the name and style of the Electric Telephone Company.

REMOVAL.—On June 15 the Edison and Swan United Electric Light Company (Limited) remove their offices from 57, Holborn-viaduct, E.C., to 14, Albert-mansions, Victoria-street, Westminster, S.W.

CRICKET.

EASTERN TELEGRAPH COMPANY (LIMITED) *v.* SUBMARINE TELEGRAPH COMPANY (LIMITED).

This match, which has been on the tapis for the past few weeks, came off successfully on Saturday last, on the ground of the Walham Green Cricket Club, Beaufort House, Fulham. The result was a disastrous one for the Continental Company.

The captain of the Eastern Company's Eleven, having won the toss, sent in the Submarine to the bowling of Messrs. McMillan and A. Jack. A very poor stand was made, only two out of the eleven making runs. This was mainly due to the very fine bowling of McMillan, who took eight wickets at a cost of 2 runs, a really splendid performance. The innings closed for 6. Play was resumed after a short interval, the Eastern Company sending in Messrs. McMillan and A. Jack. An unfortunate start was made, A. Jack being caught by Froome for 3. On Cowper joining McMillan, the score was quickly carried to 48, when McMillan, in reaching out to a ball from Muzio, was caught by Frome at point. Two wickets for 48. Macdonald joined Cowper, and the score again rose rapidly, but after scoring 8 the former was cleaned bowled by Kennett. Three wickets for 80. G. C. Jack (captain) followed next, and the bowling, which was getting weak, was completely mastered. Several changes were tried but with no effect, and it was not until the score had reached 128 that a separation took place, a ball from Kennett sending Jack back for a useful 22. Cowper, who had been playing in splendid style, was now joined by Porter, and the score was soon rattled up to 141, when a ball from Cross beat and sent back Cowper for 73. Going in with one wicket down for 6, Cowper, after nearly two hours' play, was out with the score at 141, his fine innings including 1 four, 5 threes, 17 twos, and 20 singles. Payne followed, but after making a single, played a ball on to his wicket. Palmer joined Porter, but with the score at 147 the latter was caught and bowled by Kennett for a careful 11. At this stage of the game "Time!" was called, Palmer carrying out his bat for 3, leaving the Eastern Telegraph Company winners by 141 runs with 3 more wickets to fall. Below will be found the full score:—

SUBMARINE TELEGRAPH COMPANY (LIMITED).

Mr. Cross, b. A. Jack	0
Mr. Kennett, c. Porter, b. McMillan	0
Mr. Mitchell, b. A. Jack	0
Mr. Froome, b. McMillan	4
Mr. Barnes, c. Porter, b. McMillan	0
Mr. Muzio, b. McMillan	2
Mr. Gregory, b. McMillan	0
Mr. Renouf, c. Porter, b. McMillan	0
Mr. Spong, not out	0
Mr. Butler, b. McMillan	0
Mr. Heath, c. Richardson, b. McMillan	0
Extras	0
Total	6

EASTERN TELEGRAPH COMPANY (LIMITED).

Mr. McMillan, c. Froome, b. Muzio	10
Mr. A. Jack, c. Froome, b. Barnes	3
Mr. Cowper, b. Cross	73
Mr. W. McDonald, b. Kennett	8
Mr. G. C. Jack, b. Kennett	22
Mr. F. Porter, c. and b. Kennett	11
Mr. E. Payne, b. Kennett	1
Mr. T. J. Palmer, not out	3
Extras	16
Total	147

Messrs. Richardson, Munro, and Hensman did not bat.

We sincerely hope this will not be the last match we shall have the pleasure of reporting this season between the kindred cable companies. Meetings such as these tend greatly to promote feelings of good fellowship, and the Submarine Telegraph Company are to be congratulated on having been the ones to originate this the first meeting.

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COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. MAY 26.		BUSINESS DONE WEEK ENDING MAY 26. Highest.	Lowest.
Anglo-American	31,	32	31½	31
Do. Preferred	52,	53	53	52¾
Do. Deferred	10½,	10¾	10⅜	10⅛
Brazilian Submarine	10⅜,	10⅞	11	10⅝
Cuba	10½,	10¾	10⅝	10½
Do. Preference	18,	19	18½	—
Direct Spanish	1½,	2	—	—
Do. Preference	9,	10	—	—
Direct United States Cable	8⅞,	9⅛	9	8⅞
Eastern Telegraph	10⅞,	11	11 1-16	10⅞
Do. 6 per Cent. Preference	14½,	14½	14⅜	—
Do. 5 per Cent. Debentures, 1899	105,	108	—	—
Eastern Extension	12⅛,	12⅜	12⅜	12 1-16
German Union	9½,	9⅞	—	—
Globe Telegraph and Trust	6½,	6⅞	6⅞	6⅝
Do. Preference	13½,	13½	13½	12⅞
Great Northern	12½,	13	12 15-16	12⅝
Indo-European	34,	35	—	—
Reuter's	6,	6½	—	—
Submarine	200,	210	—	—
West India and Panama	⅝,	¾	11-16	⅝
Do. 1st Preference	8⅞,	9	8⅞	8⅝
Western Brazilian	6⅞,	7⅛	—	—
Western Union 7 per Cent. 1st Mortgage	118,	122	—	—
Do. 6 per Cent. Sterling Bonds	103,	107	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	13-16	15-16	⅞	—
Oriental	3-16	5-16	3-16	—
United Telephone	12⅞,	13⅛	13⅛	12⅞

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	2⅛,	2⅞	—	—
Do. (fully paid)	4½,	4⅝	—	—
Swan	1⅜,	1⅝	1⅝	1½
Maxim-Weston	3-16	5-16	—	—

MISCELLANEOUS.

Telegraph Construction	37	38	37¼	37¼
India Rubber, Gutta Percha, and Telegraph Works	23	24	23⅜	23

Improved Gramme Machines

For Arc or Incandescent Lighting, Electroplating, or Transmission of Power, Series, Shunt, or Compound Wound.

REPAIRS TO DYNAMOS OF ALL KINDS.

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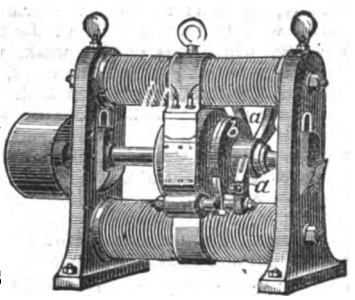
To overcome the Blinking of Gas Engines.



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Electric Light Installations carried out.

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ELECTRICIAN,

CONTRACTOR for ELECTRIC LIGHTING and ALL KINDS of ELECTRICAL ENGINEERING,

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Manufacturers of the Bernstein Incandescent Lamp. Lamps from 5 to 100 candle-power. Lamps made to fit any kind of Holder already in use.

The Company have acquired the Patent Right of the Bernstein Lamp for England and Colonies, Belgium, Italy, Russia, Spain, and Portugal, Sweden and Denmark

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WILL SPEAK WELL UP TO 12 MILES.

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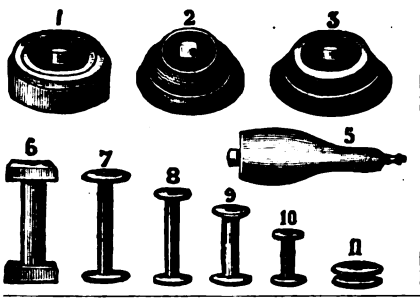

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Office: 8, Victoria Chambers, WESTMINSTER, S.W.

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Cathetometers, Micrometers, Bar Callipers, and all descriptions of Electrical, Physical, and Mathematical Instruments. Experimental work undertaken. Chloride of Silver and other Batteries. Switch Boards, Switches, and Electric Light Fittings.

Instrument Cabinet Work.

Complete Installations of Electric Light undertaken. Engines, Dynamos, Motors, and Lamps supplied.

PRIZE MEDAL, PARIS ELECTRICAL EXHIBITION, 1881

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BATTERY JARS.

TELEGRAPH INSULATORS, CHEMICAL APPARATUS, ART STONEWARE PLUMBAGO CRUCIBLES, &c.

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ELECTRICAL ENGINEERS & MANUFACTURERS.

Contractors to the Admiralty, Railway Companies, Steamship Companies and others. Makers of the Goolden-Trotter Dynamo, Electric Motors, Talenta Arc Lamp, Cardew Voltmeter, Current Gauges, Switches, Cut-outs, Fittings, &c. Battery Cells, Galvanometers, Resistance Boxes, Trotter Dioptric Diffusors. Blythswood Speed Indicator for Ships and Trains (Gold Medal at the I. I. Exhibition). Agents for Scott's Hardened India Rubber Varnish for Dynamos and Accumulator Boxes, &c.

DOMESTIC, FACTORY, AND SHIP INSTALLATIONS

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NOTES.

WENTWORTH CASTLE.—This mansion is now illuminated by 600 incandescent lamps.

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 28th May amounted to £2,823.

MANCHESTER.—Messrs. Lewis and Co., it is stated, are about to extend their electric lighting, and to adopt it at their premises in Manchester.

EASTERN TELEGRAPH COMPANY.—The traffic receipts of this company for May amounted to £50,741, against £61,327 in the corresponding period of 1885.

DIRECT SPANISH TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the month of May are £1,688, against £1,352 in the corresponding period of last year.

CAPE COLONY.—The telegraph receipts for the month of March, 1886, were only £3,000, as against £4,584 in the corresponding month of 1885, showing a decrease of over £1,500.

BELGIAN SOCIETY OF ELECTRICIANS.—At the last monthly meeting of the Belgian Society of Electricians, M. Montefiore was unanimously elected *président d'honneur*, in place of the late M. Melsens.

TASMANIA.—New Post and Telegraph Offices are to be built at Oatlands, at a cost of £1,435. The work is undertaken by Mr. J. Hogan. The building is of freestone, with a front office of 27ft. by 15ft.

THE EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY.—The traffic receipts of this company for the month of May amounted to £41,037, and to £50,016 in the corresponding period of 1885.

A CATHEDRAL STRUCK BY LIGHTNING.—A terrific thunderstorm broke over Hereford on Wednesday night. The lightning struck the tower of the cathedral, doing great damage to one of the pinnacles and to the roof of the building.

THE ELECTRIC LIGHT FOR PRINTING OFFICES.—The Electrical Power Storage Company has just completed the extension of the electric light to the printing department of Lloyd's, and the absence of heat is much appreciated.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 28th May were £2,284, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

THE FORBES THERMOPILE GALVANOMETER.—We are informed that Messrs. Nalder Bros. have been appointed by Prof. Forbes the sole manufacturer of his combined thermopile and galvanometer, a description of which appeared in our issue of March 19 last.

BRISTOL.—At the Bath and West of England Show, which opened on Wednesday last on Durdham Down, in addition to the usual telegraphic communication, there is also telephonic communication to the town, the charge being 2d. for a certain time in using the instrument.

THE WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended 31st May are £2,988, as compared with £3,862 in the corresponding period of 1885. The February receipts, estimated at £5,034, realised £5,098.

FIRE APPLIANCES AT THE EDINBURGH EXHIBITION.—The fire brigade stations within the Exhibition buildings were originally connected by means of mechanical telephones, but this, having been found unsatisfactory, has been superseded, at the request of the Exhibition Committee, by the National Telephone Company's system of fire alarms.

CRICKET.—In reference to the report of the cricket match between the elevens of the Eastern Telegraph Company and the Submarine Telegraph Company, we are asked to say that the eleven representing the Submarine Company was a "scratch" eleven, selected from the accountant's department exclusively, and not the representative eleven of the club.

THE SIMS TORPEDO.—This torpedo, which has been adopted by the United States, is manœuvred, governed, and exploded by electricity. It carries in an after compartment a long length of cable containing the conductors, by means of one of which the apparatus of propulsion is controlled, by the other the direction. Two powerful electro-magnets are used with the latter.

THE ELECTRIC LIGHT AT THE WEST END.—On the 26th and 29th May the Indian Room at Marlborough House was again lit throughout by the electric light, the installation being, as before, carried out by the Electrical Power Storage Company. They also carried out on the 26th an installation of over 100 lights of 20 candle-power at Dover House, which was repeated on the 29th.

"THE MONTHLY CORRESPONDENT."—It is a great pity that the Madeira editor of this lively little Telegraphic Journal should permit a correspondent to occupy over five columns with a letter on "Home Rule," in which the said correspondent shows utter ignorance of the whole subject. If he would begin to learn, perhaps he might with advantage commence by reading Spencer's essay on the subject of Ireland.

THUNDERSTORM IN A CLEAR SKY.—Captain Anderson, of the British barque "Siddartha," which lately arrived in New York, reported a peculiar thunderstorm on April 27, while on the northern edge of the Gulf Stream. The sky was quite clear at the time, and the sun shining brightly, although there appeared to be a thin mist about the ship. Suddenly there appeared a vivid flash of lightning, accompanied by violent thunder. The compass was caused to vibrate perceptibly for a period of fifteen minutes.

CONFERENCE OF TELEGRAPH CLERKS.—The annual conference of telegraph clerks was held at Swansea on the 29th ult. Twenty-four delegates, representing Birmingham, Manchester, Liverpool, Gloucester, Belfast, Cardiff, Dublin, Newport, Monmouth, Hull, Bristol, Leeds, Swansea, and other places, were present. Several matters connected with the status and interests of the telegraph profession were discussed. Letters were read from a number of members of Parliament expressing sympathy with the movement.

ELECTRIC LIGHTING IN A TOBACCO MANUFACTORY.—Messrs. Mather and Platt have recently completed an installation of 700 lamps in the extensive new tobacco and cigar manufactory of Messrs. W. D. and H. O. Wills, Bristol. The building is lighted throughout by sixteen 20 candle-power Swan lamps, and no gas has been laid on except for heating purposes. Two 500-lamp Edison-Hopkinson dynamos, running at a speed of 700 revolutions per minute, have been supplied for this installation, either of which is capable of maintaining the whole number of lamps usually in use at one time.

PUBLIC PROPERTY.—In a paper by Mr. C. J. Kintner, on "The History of the Electrical Art in the United States Patent

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Office," read before the Franklin Institute, the author says:—"It is a remarkable fact that by a strange chain of coincidences many of the leading and essential features embodied in successful incandescent and arc lighting and also in dynamo machines to-day are public property. It is only upon comparatively limited patents that existing light corporations are based, and this rightly by virtue of abandonment or public use on the part of the original inventors of these broad features."

LIVERPOOL.—It will be remembered that we mentioned the fact, in connection with the Queen's visit to open the Exhibition at Liverpool, that a telephone line had been laid from the theatre to Newsham House. The judges recently on circuit have utilised this telephonic connection in hearing the performance at the theatre. There is nothing new in the transmission of music by telephone, but if the system ever came into extensive use, it seems to us that the managers of the various theatres might very well exact a small charge for every telephone so connected. This might add somewhat to their revenue.

FURTHER PROGRESS.—It is well understood that the future of the telephone is very great, but we hardly supposed that it would have found favour in athletics. At the Darlington athletic sports, however, we notice that there was a telephonic apparatus between the dressing tent of the competitors and the centre of the field, from whence announcements were made of the competitors who were going to run. A Byng acoustic telephone and an electric bell were fitted up by Mr. E. Cox-Walker. In all probability we shall next have an underground series of wires radiating from the popping crease at Lord's and the Oval so that those interested in cricket may hear when their respective champions make good hits.

ELECTRICITY AND LIGHT.—According to *L'Elettricità*, MM. Aubel and Spring have lately been making investigations in connection with the relations between electricity and light. M. Aubel had suggested that we ought to have the same phenomenon with a dielectric in a magnetic field as with the conductor in Hall's phenomenon—that is, we ought to have a rotation of the equipotential surfaces or lines, and, therefore, of the force lines and polarisation in the dielectric. To see whether this was the case, he made use of sulphur, whose specific magnetic power is greater than that of glass, formerly employed by Hall in a similar investigation. He failed to obtain any result, however much he increased or varied the field.

SPANISH COLONIAL TELEGRAPHS.—Spanish advices report the holding of a meeting in Madrid of deputies and senators from Puerto Rico, with a view to concerted action in pressing upon the Government the necessity of various measures required in the interests of that colony. One of these subjects was the question of a direct telegraph cable to the Antilles. A committee was appointed to wait upon the Minister for the Colonies with the request that he would facilitate by every means in his power the proposal of the Canary Company to lay a cable between the Canary Islands and the Spanish Antilles. It was also decided to invite the co-operation of the Cuban representatives in securing a direct cable as the only means of obtaining a reduction in the high prices now paid for telegrams to Europe.

PHILIPP REIS'S TELEPHONE.—A large number of German publications, says M. W. Van Benthuysen in the *Scientific American*, printed from 1860 to 1865, "contain accounts of the transmission of the words and articulate speech by Philipp Reis with electricity, and the instruments as made by Reis do now transmit and receive articulate speech clearly and distinctly, and I maintain that if only five words were so transmitted the discovery of its being done with electricity by Philipp Reis is conclusive, and that no honest or intelligent person can concede to Bell what was done and given to the world unconditionally fifteen years before by Philipp Reis. All subsequent efforts are merely mechanical improvements, and no honest man acquainted with the subject can dispute the discovery by Philipp Reis."

ELECTRICAL PURIFICATION OF COPPER.—Messrs. Sir Hussey Vivian and Sons, of Swansea, about a month ago purchased from Messrs. Mather and Platt, through the Edison and Swan Company, one of the largest dynamos hitherto constructed for electrolytic purposes. It has an output of 50 volts, 1,000 amperes, at 400 revolutions. The weight of the entire machine is $5\frac{1}{4}$ tons; the magnet limbs are solid forgings, each weighing 22cwt., and are shunt-wound only, each limb having 260lb. of copper wire. The armature is constructed of bars 0·338 square inch area, and has a resistance as low as 0·0016 ohm. The commercial efficiency of the machine is over 93 per cent. This dynamo has given such satisfaction that Messrs. Mather and Platt have recently received an order from the same firm for a second precisely similar machine.

FOLKESTONE EXHIBITION.—The lighting of the Folkestone Exhibition was successfully started on the night preceding the opening of the Exhibition, on which occasion it was run until one o'clock, in order to facilitate the completion of the exhibits. The lighting of the pictures hung in the side galleries by means of double clusters of incandescent lamps was thoroughly successful, the arc lamps also showing to good effect in the high central nave and grounds round the Exhibition. It is proposed to utilise the building, if possible, at the close of the Exhibition as a permanent winter resort, for which doubtless the electric light will be retained. The Electrical Power Storage Company, who undertook the work, have received flattering reports from the Folkestone authorities as to the way in which the work has been carried out.

ELECTRIC BICYCLES.—M. Henri de Graffigny, a member of the French scientific press, has recently been amusing himself with the application of electricity to a bicycle, on which he made several successful journeys. *Electricité*, which gives some interesting details of the experiment, concludes an article by saying that with these machines, when the accumulators are properly charged, one may travel a distance of 300 to 400 kilometres without experiencing the least fatigue, and at a speed equal to that of an ordinary railway train. As our readers know, the experiment is not by any means a new one, having been tried by several gentlemen in this country two or three years ago. The results obtained then were not such as to lead us to share the sanguine views of our contemporary as to the future development and popularity of electricity in this direction.

ELECTRIC MOTORS.—Dr. P. H. Vander Weyde, in a paper on "Some Early Experiences with Electro-motors," read before the New York Electrical Society on May 12th, divides electro-motors into three classes:—1. Soft iron armatures alternately attracted by electro-magnets and *vice versâ*. 2. Steel magnets attracted and repelled by electro-magnets and *vice versâ*. 3. Electro-magnets attracted and repelled by electro-magnets. Each of these three classes may be operated upon the principle of to-and-fro or reciprocating motion, having a crank connection, like the piston movement of the steam engine; or they may be operated upon the rotary principle, which appears to be the most advantageous in the application of electricity to power, especially when the Pacinotti ring principle is used,

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which has wrought a revolution in motors as well as in dynamos.

MERSEY RAILWAY.—Mr. Fox, in his paper before the Institute of Civil Engineers, stated that the stations on this railway were lighted with gas, he being of the opinion that so long as the smallest uncertainty existed as regards the regularity of electric lighting, the railway company was not justified in employing electricity as a lighting agent, unless, indeed, gas was laid on as a stand by. The installation at Paddington will, perhaps, open the eyes of Mr. Fox as to the capabilities of the electric light, and the confidence it inspires. At this time of day it is too late to talk about the non-certainty of the electric light, because any electrical engineer of repute will as certainly provide against a breakdown as the railway companies do in the case of engines. We maintain that electricity is as certain as gas, and far more safe and pleasant.

METROPOLITAN BOARD OF WORKS.—In the report of the Metropolitan Board of Works for 1885, just issued, some three or four pages of the report are devoted to the consideration of telephone and telegraph wires, stating at some length the position of the Board of Works in relation to these matters, and the suggestions of the Select Committee after having taken evidence. We have already commented upon some of the absurd suggestions made, and especially that which would give permission to pass wires over property without the owners or occupiers having the right of prohibition. This report concludes: "It is now, apparently, for the Government to consider whether the Legislature shall be asked to pass a Bill framed in accordance with the suggestions of the Select Committee." We are strongly of opinion that no Government that has existed—or ever will exist—will be able to pass a Bill containing these suggestions, several of which are altogether in opposition to the general tenor of legislation.

DIELECTRIC CAPACITY.—Some experiments on the dielectric capacity of gases at 0° C. and 760 mm. have lately been made by Klemencic, who gives the following table. The corresponding table of refractive indices are those determined by M. Mascart:—

	$\sqrt{K}$ (K = specific inductive capacity).	μ (= refractive index).
Air	1·000293	1·0001927
Hydrogen	132	1387
Carbonic acid	492	4544
Carbonic oxide	347	5350
Protoxide of nitrogen	579	5159
Ethyline	728	7200
Sulphuret of carbon	145	1478
Sulphurous acid	477	7040
Ether	372	1537
Chlorethyle	766	1674
Bromethyle	773	1216

It can be seen that for the last four gases the square root of the specific inductive capacity is no longer comparable to the index of refraction.

TELEPHONY.—We take the following from our American contemporary the *Electrical World*. When the instruments and experimentalists reach Liverpool we may have something further to say on the matter:—"The following is the account given by a Cleveland despatch of a recent telephone test between that city and New York: A public telephone test was given this afternoon between this city and New York by Count Mitkiewicz, representing a Baltimore invention. The wires were made up so as to make as long a distance as possible, and covered a circuit of 1,600 miles. A very large and select party of capitalists, &c, witnessed the test, a special feature of which was the singing of Miss Emma Abbott and Miss Bellina, of the Abbott Opera Company, both of whom were interested witnesses of the test. Seven receivers were attached at one time, so that that number of persons could hear at the same time. Songs were also sung by the parties at New York, all of which were most distinctly heard by every one at this end. A test across the Atlantic Ocean will be made as soon as the parties, who are now on their way, reach Liverpool with the instruments."

THE ALBERT PALACE, BATTERSEA.—The electric lighting for the Albert Palace is to be on an extensive scale. A large open-air theatre is being erected in the grounds in imitation of the Cafés Chantants of Paris, and among other attractions there will be a ballet. The front of the proscenium is to be illuminated by a double row of incandescent lamps, while a powerful arc light is to be placed on the top of the band stand opposite to, and directed on, to the stage. A number of tall venetian masts are to be placed in the grounds, having an arc lamp on the top of each, while from post to post and thence to the top of the band stand thousands of coloured incandescent lamps are to be suspended in festoons. The interior of the palace itself will be lighted during the summer months with arc lamps, to which are to be added some two thousand incandescent lamps during the winter when the outdoor attractions are over. A new and capacious engine house is in course of erection, and the Jablochkoff and General Electricity Company, who have taken the contract for the lighting, have arranged with Messrs. Hornsby and Sons to supply two powerful steam engines with all their latest improvements.

BLUNDERING WITH DYNAMOS.—The following appears in the *Machinery Market*, a periodical devoted to "trade," and not to "science." We confess to an utter inability to understand the references. Was the lubricant applied to the bearing or to the "commutator?" The terms are, or seem to be, used by the writer indiscriminately. Yet, the bearing is not the commutator, nor the commutator the bearing:—"It often occurs in establishments supplied for the first time with electric appliances that engineers and others are placed, after a short period of instruction, in charge of dynamos and electric motors. To these men, experienced as they may be in steam engineering, the introduction of electrical terms, and the unfamiliar terms given to machines and their parts are mystifying. In one of our large factories, after the dynamos had run only a few hours, the bearings of the commutator showed signs of heating. Following out the practice pertaining to similar difficulties in the steam engines, the engineer tried the effect of plumbago mixed with lubricating oil. The result might have been expected; the plumbago applied to the commutator being an excellent conductor, a short circuit was formed, rendering it necessary to stop the dynamo until the difficulty was remedied."

SKINNING BY ELECTRICITY.—One of the latest American inventions is an "electric siding-knife," for skinning the carcases of animals without injuring the hides. In the immense slaughtering houses in the United States there is often a rush of business, and unskilled labour is frequently employed in the skinning of oxen and other animals, with the usual result that hides are seriously deteriorated in value by accidental cuts of the knife. As many of these establishments have an electric lighting plant which is lying idle during the day, it occurred to a Mr. Newgass, who has been for many years manager of one of the large canning companies, that the current might be utilised for flaying the animals, and he has accordingly invented a siding-knife, in which a platinum wire is raised to incan-

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descence by the electric current, and the hides are burnt off, so to speak, instead of being cut off. The preliminary cut is made with the ordinary knife and the butcher then takes the electric tool, in which the incandescent wire is shielded by guards, so that neither the flesh nor the skin is injured, and with long, quick sweeps the hide is separated from the carcase in an expeditious and cleanly manner, and is found to be worth about a cent a pound more than those taken off with the ordinary flaying knife. When the meat is required for freezing and exportation, a further advantage is said to be found, for the incandescent wire, by closing the pores of the flayed surface, preserves the colour of the meat, and the sides of beef and carcases of mutton do not sweat, or "weep," when removed from the chill room, as in the old-fashioned method of skinning. The cost of the current is stated to be more than covered by these advantages, and the little skill necessary for using the electric "sider" is readily attained.

West African Cables.—On May 22nd, the cable ships, the "Dacia" and "Buccaneer," owned by the Silvertown Company, left the Thames, *en route* for the West Coast of Africa, and laden with cable for the continuation from Konakri along the African coast of the West African Telegraph Company's system, which already extends to the French settlement of Konakri. The first work upon which the ships will be engaged is the connecting of Bathurst to the Cape Verde islands, on behalf of the African Direct Telegraph Company. Konakri and Sierra Leone will thus be placed in communication, and the heavy cables for the shore ends at Grand Bassam, Accra, and probably Porto Novo, will afterwards be laid. The ss. "Silvertown" will sail about the end of June, and will lay the main cable between those points at which the "Dacia" will have landed the shore ends. She will then proceed to continue the West African Telegraph Company's system to S. Thomé, Principe, Gaboon, and S. Paulo de Loanda. The Telegraph Construction and Maintenance Company are sending out their "Britannia" and "Scotia" to lay, under contract with the African Direct Telegraph Company, a section between Bathurst and Sierra Leone, thus duplicating the West African Telegraph Company's communications to the latter place. The same firm will then connect Sierra Leone with Accra, and this section will be employed as a common line for the West African Telegraph Company and the African Direct Telegraph Company. From Accra the latter company's cables will be continued on to Lagos, and to the mouths of the River Niger. We are informed that the Colonial Office has conceded an extension of time to the Telegraph Construction and Maintenance Company for the completion of their work, due to the fact that the "Scotia" will require to make two trips. The "Dacia" is reported as having left Lisbon on her way to the coast on May 29, after having received on board the representative of the Portuguese Government. The "Buccaneer" arrived at St. Vincent on June the 1st, and will proceed thence to Bathurst, where she will join company with the "Dacia."

Gas Lighting in Spain.—The Spanish papers still continue to discuss the disputes that have arisen between the consumers of gas and the gas companies in Madrid and in Cadiz. In view of the probable early completion of arrangements for the installation of the electric light by the Edison Company, to which we alluded last week, the Madrid Gas Company has addressed a very polite circular to its customers, in which it expresses its desire to comply with their wishes, and in which it lays all the blame for the present dispute on the committee of the Mercantile Club. In reply to this circular, a member of the club writes to the *Dia* to explain the circumstances of the case, from which it appears that five or six years ago a committee to represent the consumers petitioned the company in favour of a reduction in price and improvement in the quality, upon which the company offered to lower the price of gas when the railway in the coal fields of Asturias should be completed; and further to place a testing apparatus in the Mercantile Club. It is affirmed that the extension of the railway system in the North Eastern provinces has taken place, but that the company has not carried out either of its promises, while the present conditions proposed by the company now are a prolongation of its monopoly for 29 years, in return for a reduction of 10 per cent. now and another 10 per cent. in the space of ten years. These terms have been rejected by the Consumers' Committee, and there is no appearance of the matter being amicably settled. Meanwhile the trading community, headed by the dealers in textile goods, have abstained from the use of gas since the 15th ultimo, and pending some satisfactory arrangement for the introduction of the electric light, are lighting their premises with oil lamps, those most in vogue being apparently the American system known as the "Rochester," and the Vulcan lamp. As regards the conflict in Cadiz between the present French company and the proposed local Spanish company, a committee has left for Madrid to lay the views of the community before the Government. The *Dia* of the 28th May publishes a telegram received by one of the Committee to the following effect:—"The new light by means of electricity and petroleum has been inaugurated amidst indescribable enthusiasm and illuminations, the thoroughfares being crowded by thousands of the population." As the deputation to Madrid is to obtain the cancelment of the order forbidding the formation of a local gas company, it is to be presumed that the electric light referred to is of a private installation, and may or may not be of a permanent character.

Two New Radiophones.—M. Mercadier, in a paper to the *Journal de Physique*, states that all known radiophones may be divided into two classes:—I. Those in which the transformation of radiant energy into mechanical energy, in the form of sound, is effected *directly*. The radiant energy might be that of the heat, the light, or the ultra violet rays, and the apparatus might be respectively termed thermo-, photo-, and actino-phone. We have examples of the former two, but not of the last. II. Those in which the above-mentioned transformation is *indirect*, and there are one or more intermediate transformations. The photophone of M. G. Bell is of this kind, and in this the intermittent radiations act on a layer of selenium, of alloys of selenium and tellurium, or of lamp-black, placed in a circuit containing a battery and a telephone. In this case it is known that it is principally the luminous radiations which act, producing in the circuit variations of electrical energy, whence result the sounds in the receiving telephone. Such instruments might be called photo-electrophones. The author says he has invented two new kinds of indirect radiophones of the thermic kind. First, he has shown that a microphone is sensitive for the action of intermittent radiations. It is sufficient to take an instrument of this kind where the supports of the carbons are fixed to a thin plate or diaphragm of varnished deal and united to a receiving telephone, either with or without an induction coil in the circuit of the battery. By exposing the diaphragm to the action of intense radiations, which are rendered intermittent (for example, by means of a wheel with holes in it), sounds are heard in the telephone whose pitch varies in a continuous manner with the velocity of the wheel. Secondly, he has shown that any transmitting telephone is equally sensitive for the same

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action produced on the iron diaphragm. The sounds produced are much the same as in the former case. In both cases the diaphragm of unpolished deal or iron ought of necessity to vibrate in absorbing superficially the thermic radiations (perhaps in the case of the iron the magnetic properties also may be affected by the warmth). They may be called thermophones. The first might be called a thermo-electrophone, the second a thermo-magnetophone. The effect may be intensified—(1) By smoking the surface of the wooden or iron diaphragm; (2) by confining a layer of air in front of the smoked diaphragm by means of a piece of glass or mica; (3) by augmenting the intensity of the source of light. They are feeble, with the oxyhydrogen light, but are strong with electric, and still more with solar light.

CHOICE OF METALS FOR CONDUCTORS.—M. E. Bède, lecturing the other evening before the Belgian Society of Electricians on the choice of metals for the wires of telegraph and telephone lines, observed that since the achievements of M. Van Rysselberghe, telegraph lines must not be considered separately from telephone lines. M. Eric Gérard, in his recent lecture before the Society at the Montefiore Electro-Technical Institute, pointed out that in accordance with Hughes' experiments in self-induction, and those which he himself had conducted at the Electro-Technical Institute, that to transmit equally for an alternating current with very short undulations, like telephone currents, iron wires must be employed of a slightly larger diameter than that of a copper or phosphor bronze wire of high conductivity. Consequently, the weights of the two lines in iron and in phosphor bronze—equally good for telephonic transmission—would be in the ratio of 32 to 1, and as the price of galvanised iron wire is more than one-eighth that of the bronze, it follows that a line laid with iron wire would cost at least four times the amount of an equally good line in phosphor bronze wire of high conductivity, without taking into consideration the fact that, being thirty-two times heavier, it would require much more costly supports and labour. From the beginning of telephone exchanges M. Bède had adopted for the wires the phosphor bronze of M. Montefiore, and the results had always been excellent. Now almost all the telephone companies had followed this example, and it had been found possible, with phosphor bronze wire of great tenacity, to span whole valleys of 800 metres (875 yards) without intermediate supports. After M. Bède's lecture, M. Banneux, Inspector of the Belgian State telegraphs, declared that this Administration has decided to replace all the iron wire lines as they became defective by those of phosphor bronze, and had already given some large orders to M. Montefiore. M. Van Rysselberghe then declared that, judging by his experience in America, it was not possible to establish good telephonic transmission to long distances by means of iron wires, while with those of copper excellent results were obtained. It was thus that he was not able to correspond properly at a distance of 250 miles by means of iron wire of 4½ mm. diameter (No. 8), while he corresponded perfectly well from New York to Fostoria, a distance of 730 miles, with a hard copper wire of 2·7 millimetres, and from New York to Chicago (1,010 miles) with a compound wire, formed with a steel core of three millimetres, surrounded by a thickness of 1·5 mm. of copper, corresponding to a 5 mm. copper wire. It was certain that communication could be established by telephone with such a wire at 2,000 miles distance, so as to give commercially satisfactory results.

MEETING OF TELEGRAPH BOYS IN PARIS.—It is not often that we have a ludicrous side to telegraphy, at any rate so far as the messenger boys are concerned; but the correspondent of the *Daily News* at Paris has given matter for a good laugh, if for nothing else, and at least two daily papers have thought the matter sufficiently interesting to have leaders upon it. We give the *Daily News* account, and wonder whether China has not imposed her civilisation upon this western land:—"The Liliputian corps attached to the telegraphic service have held their indignation meeting at the Salle Tessier, at Grenelle. Only a single boy in active service went in uniform, and he had the collar bearing his number turned down to hide it. To the great concern of the poor little fellow, Johne, the leader of the movement, insisted upon his acting like a man and showing the whole of his collar. The other youths who came to air their grievances were in plain clothes. There were a good many others who had been turned off for letting Johne persuade them to strike. He is now a printer's devil. The unfortunate lad in uniform was called to the chair, but proved an honorary chairman, the effective one being the instigator of the strike—the Citizen, or as some termed him *le compagnon* Johne. He looked a singularly self-assured youth. Johne related his experience as a member of the Juvenile or *Petits Bleus* Telegraphic Corps with a seriousness which did not appear to strike his youthful hearers as ludicrous. He complained that the administration and the adult clerks and messengers had not a proper amount of consideration for the dignity of the boys, and treated them with disrespect. They were actually made to take turns in sweeping the offices and lighting the fires, just as if they were not *employés* of the State, and governed by the same laws of advancement as their elders. The grown-up clerks and messengers spent their leisure in paring their nails and jocular conversation, or in writing poetry, novels, and love letters, whereas the boys were not allowed to use pen and ink unless to copy literary extracts by way of punishment. It was here explained that their salaries being too miserable to admit of fines, they had to write out impositions as in school, and there were boys who had often to get through a couple of hundred lines of Corneille, Racine, or some other poet whose works they thought a bore. They were not allowed to play cards or read the journals, although there were always newspapers lying about. If any *bourgeois* made any complaint against them, whether for asking for a gratuity, or being a little late, or showing impatience when rings at door bells were not quickly answered, they were dismissed. Johne was sent about his business for asking a *bourgeois* who offered him a sou, whether he had not more small change than that, and returning to him the copper coin, not that he valued money half so much as dignity. One day he gave a telegram to a foreign prince at the Grand Hotel. His Royal Highness threw him a five-franc piece piece, but with such an air of contempt that Johne on picking it up placed it on the table and said, 'My humble means enable me, Monseigneur, to live without accepting this gratuity.' The young orator wound up by apostrophising *la révolution sociale*, the only revolution that would deliver young telegraphic messengers from their oppressors. This part of his speech was warmly applauded, not only by the juveniles, but by about 100 adults. An Anarchist then demanded *la parole*, which poor little Doucet, the shy chairman, granted him, and he thanked the young for having set a good example to the old. The chairman then rose to address the meeting, but broke down. All he could say was, 'I am not used to public meetings, but trust on some future occasion I shall acquit myself better.' It was then announced that the great Johne was to convoke a monster meeting, and that he and some young compositors whom he knew would print the placards for nothing. He hoped in the meantime that his young friends would think well about what they had to say, so as to be able to defend their cause if orators rose to contradict them."

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THE STEAM ENGINE INDICATOR.—XVII.*

BY AMICE.

Having now sufficiently described the principle and mode of action of most of the systems of compound engine in use, we will, in the order in which we described them, deal with indicator diagrams taken from each kind; but we will first take an ideal diagram to show what we should expect to get from a compound engine if made of non-conducting materials, so that there would be no loss of heat by radiation or conduction, and also, supposing that there be no loss of steam in parts or spaces in passing from one cylinder to another. Then the diagrams (Fig. 49) would represent what the indicator would obtain from the two cylinders of an engine without an intermediate receiver. Steam enters the high-pressure cylinder, as shown by the line L B, and is admitted during about two thirds of the stroke, as seen by the line B C. From C to the end of the stroke the piston is moved by the expanding steam, as shown by the line C D. At D exhaust takes place, but instead of the steam passing into the atmosphere and the pressure falling to E, as it would in the simple engine, and be indicated by a line D E, it passes into the second cylinder, and the entrance line F G is drawn by the indicator pencil. As the second cylinder has not an inexhaustible supply of steam, but only that which has come from the high-pressure cylinder, the pressure falls from the moment the piston commences to move, and the whole admission line GH is an expansion line, and is seen, by putting the two diagrams in the relative positions shown in Fig. 49, to be a continuation of the expansion line C D of the high-pressure cylinder.

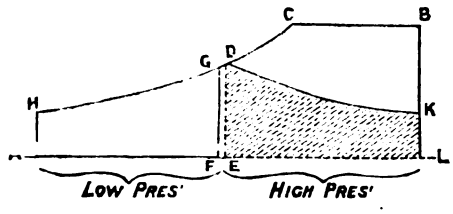

Fig. 49.

Thus far we have looked only at one stroke of the high-pressure piston, namely, that from B to D, and the one stroke of the low-pressure piston from G to H. We have, however, to observe that whilst the low-pressure piston was performing its stroke with pressure varying as represented by the height above A L of the line G H, the high-pressure piston was performing its return stroke with a back pressure, D K, equal to the pressure in the low-pressure cylinder. The back pressure against the high-pressure piston is thus equal to that indicated by the shaded part of the diagram, and only the area included within K B C D represents effective work. Such would be the diagrams under the ideal conditions. In practice, however, all the adverse conditions which we, for purposes of explanation, excepted, come into play, as will be more fully seen hereafter. We have, moreover, for simplicity of explanation, assumed that both the diagrams of Fig. 49 are taken with the same spring, or are of the same scale. This, of course, is not the case in practice, as the spring, which would be stiff enough to give a good diagram from the low-pressure cylinder, would be quite unsuitable and of insufficient strength for the indicator when on high-pressure cylinder.

It is usual with engineers to compare the practical indicator diagrams from compound engines with the theoretical, and with each other, by reducing the length of the high-pressure diagram in proportion to the relation between the area of the high-pressure piston and the low-pressure-piston. By this means the high-pressure diagram may be placed above the low-pressure diagram, as shown in Fig. 50, instead of end to end with both to one scale, as in Fig. 49, and not only is the expansion curve of the high and low-pressure diagrams brought into position for inspection as to the action and behaviour of the steam, but the amount of loss of steam pressure between the two cylinders, as shown by the gap which occurs between them even when they are placed as close as possible. This gap is seen at C, Fig. 50, A and B being the high and low-pressure diagrams. These are, however, diagrams such as would be obtained from an engine with a receiver, while the two diagrams (Fig. 49) are supposed to relate to the theoretical engine without receiver and with cylinders assumed for explanatory purposes to be of the same size. Before following up the method pursued in redrawing actual diagrams for comparing them with each other and with theoretical expansion curves, we will look at a few actual diagrams.

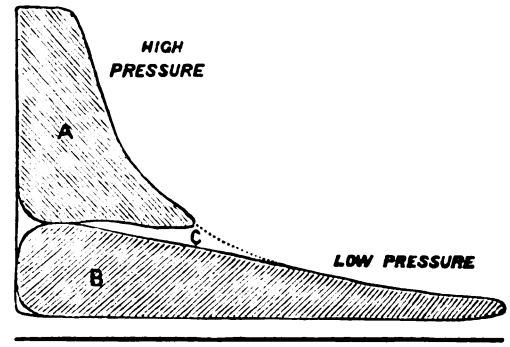

Fig. 50.

Commencing with those from a small engine, we have the diagrams given in Fig. 51. These are from a small vertical tandem condensing engine. The cylinders were respectively 4·5in. and 7in. diameter, the stroke being 10 inches. The two diagrams were taken with different spring, the high-pressure diagram we reproduce being taken with one which compressed $\frac{1}{80}$in. per lb. pressure, or whose scale was 80lbs. to the inch. The engine made 180 revolutions per minute, and at this speed gave 12·53 indicated horse-power. An inspection of these diagrams reveals a very satisfactory division of the work between the two cylinders, but there is a good deal more loss of pressure by the steam in passing between the high and low-pressure cylinders than is necessary, and much of this seems to be due either to restricted passages or to unsatisfactory action of valves, though most of it was no doubt due to condensation in the exterior pipe connecting the low to the high-pressure cylinder and in the latter cylinder itself. It will be seen in both diagrams at A' that the momentum of the indicator parts under the influence

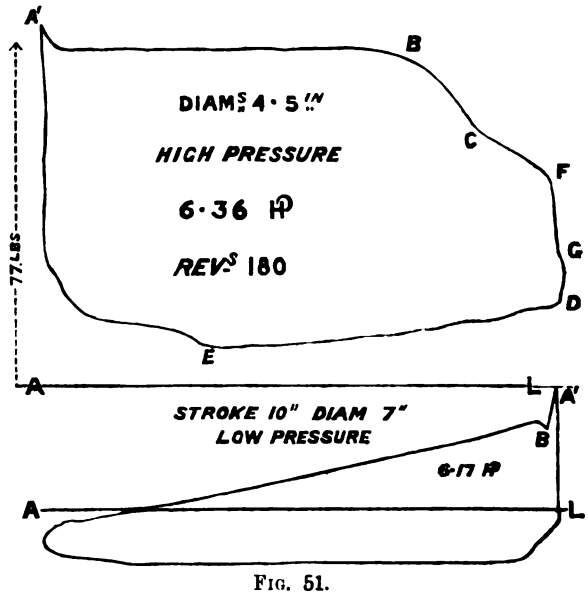

Fig. 51.

of the pressure and speed carried the pencil above the actual pressure, the recoil carrying it down to B in the low-pressure diagram before steadiness was attained. Full steam, it will be seen, was admitted to the high-pressure cylinder during about three fourths of the stroke, cut-off taking place near B, from which point pressure fell very rapidly, but became suddenly checked in its fall at C, probably by re evaporation. Exhaust occurred

* For Art. 16, see *The Electrician* 14th May, 1886.

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freely at F, except for the slight check at G, probably caused by the low-pressure piston reaching the end of its stroke. From D the pressure falls steadily, though less fast than that in the low-pressure cylinder, until the point E is reached, the valve closes, and compression commences. The relations between the areas of the cylinders being as 15·9 to 38·48, and assuming the cut off to be at about three fourths or 0·75 of the stroke in the high pressure, the actual range of expansion was only about $\frac{38{\cdot}48}{15{\cdot}9} \times 0{\cdot}75$ or 3·2. This is not enough, even in so small an engine, to secure the advantages derivable from the compound system. Such a range of expansion could be at least as economically used in a single cylinder or simple engine.

The diagrams (Fig. 52) are copied from a tracing of the indicator diagrams from a small horizontal tandem engine of the same class, namely, non-receiver class, but the passage between the two cylinders is proportionally much larger than in that from which diagrams (Fig. 51) were taken. It may be remarked that tracings from diagrams are not always exactly like the diagrams. This will be seen hereafter. The cylinders are 7·25 and 13·25 respectively, the stroke being 18in., and the number of revolutions 100 per minute. The steam pressure in the boiler was at the time the diagrams were taken 65lb., or an absolute pressure of 80lb. The maximum pressure in the high-

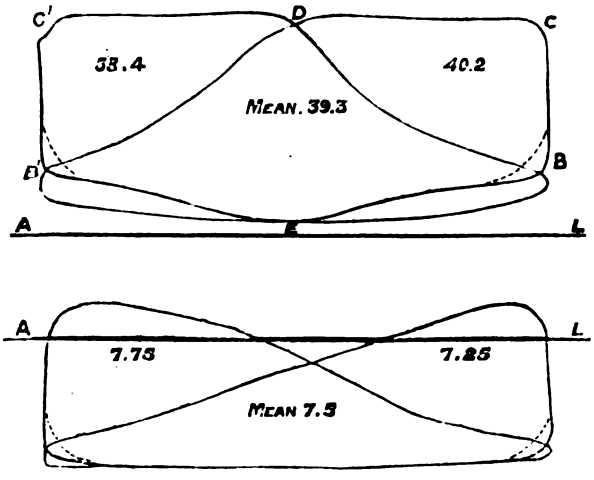

FIG. 52.

pressure cylinder reached 63lb. or 78 absolute. Steam was cut off at about half stroke, and the mean pressure taken from the two high-pressure diagrams is 39·3lb., and the corresponding mean in the low-pressure cylinder is 7·5lb., the pressures at either end of the low-pressure cylinder being more nearly alike than in the high-pressure, although even there the means are not remarkably dissimilar. It will be seen that the slow closing of the valves caused a gradual rise in the back pressure in the high-pressure, as shown by the line from E to B, or E to B'. The indicated horse-power as measured from these diagrams was 13·75 in the high-pressure cylinder, and 9·39 in the low, or a total of 23·14. For satisfactory working the heel B B' of both diagrams should be less sharp. For 100 revolutions per minute, a curve such as shown by dotted lines would have given a better result with this engine. A slight difference in the rapidity of port opening is seen at C and C'.

Figs. 53 are from the same engine working at 90 revolutions per minute, and more cooling water passing through the condenser, thus producing a better vacuum. These diagrams have been more faithfully reproduced. They show better action at the compression end of the stroke, but the improvement is marred by the defective action of the valves and by excess of compression, especially at B. Re-evaporation is plainly seen in the too slow and irregular fall of the high-pressure expansion line. An undesirable difference in the admission and early expansion of the right hand low-pressure diagram is seen at B, and it will be seen that this is accounted for by the shorter periods of admission to that end of the high-pressure cylinder from which the steam came, namely, the left-hand end, as seen at C. In both Figs. 51 and 52 the diagrams were taken to a scale of 30lb. and 8lb. to the inch respectively. We may now take an example from a large compound tandem with no other receiver than that provided by the large pipe connecting the

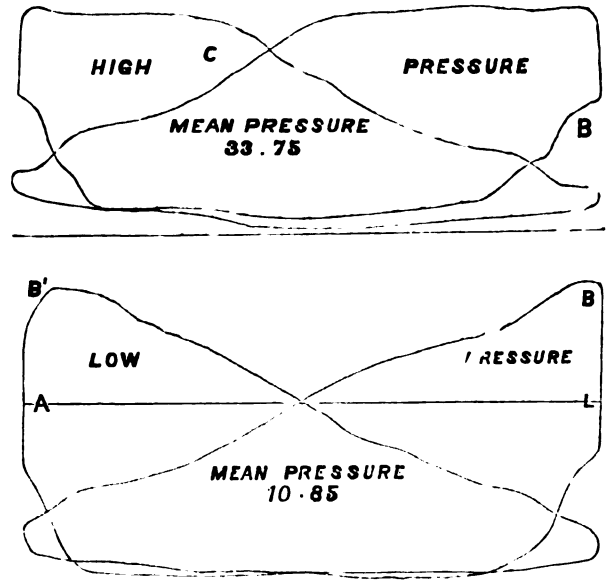

FIG. 53.

two cylinders. The diagrams (Figs. 54 and 55) are the high and low-pressure diagrams from a large horizontal tandem pumping engine, fitted with differential valve gear, and making from ten to eleven strokes per minute. They were taken to scales respectively of 32lb. and 16lb. to the inch, but, like the preceding diagrams, are reduced in size for our purposes. The engine cylinders are 45in. and 72in. respec-

FIG. 54.

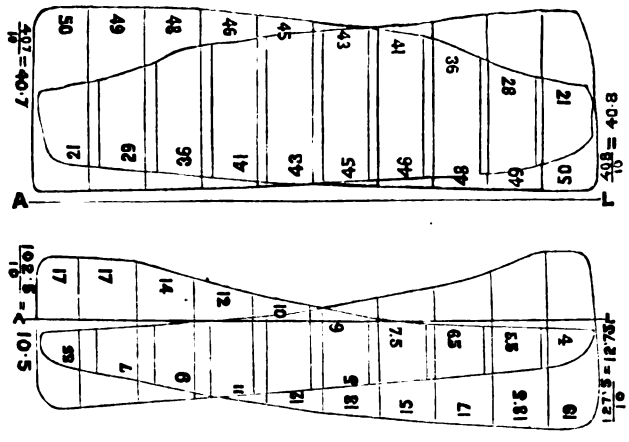

FIG. 55.

tively, and the stroke 9ft. The high-pressure diagrams, of which one pair is here shown, give a mean pressure of 40·75lbs. per square inch, and the area of the cylinders or pistons being 1,590 square inches, we have, with 10 strokes per minute (1,590in. × 40·75lbs. × 90ft.) ÷ 33,000 = 176 horse-power indicated. Two corresponding low-pressure diagrams, taken immediately after, but at a time when the speed had reached 11 strokes per minute, gave a mean pressure of 11·5lbs., and the area of the cylinder being 4,071·51 square inches, we have (4,071in. × 11·5lbs. × 99ft.) ÷ 33,000 = 140 horse-power, or a total of 316 horse-power. It will be seen that these high-pressure diagrams are satisfactory in every respect, except in the restricted admission shown by the right hand diagram; but the low-pressure diagrams show an insufficient capacity in the condenser, the vacuum being but slowly formed, or, rather, very slow in reaching its maximum.

The diagram shown at Fig. 56 is taken from a tandem non-condensing engine of the type shown by Fig. 46. The engine, nominally of 10 horse-power, was tested in comparison with

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an ordinary 10-horse portable engine by the same makers, and was said to make a very satisfactory performance. Both high and low-pressure diagrams are taken by the same spring, and the arrangement of the engine gives the diagrams in a relative position which permits immediate comparison of the actual area with the total area it would have if there were no gap. That is to say the diagrams are placed with the exhaust end of the high-pressure diagram immediately above the admission end of the low-pressure diagram. Following the steam, we may commence at B with the admission of steam from the boiler with the high-pressure cylinder, the pressure rising to C with but little restriction; full-pressure steam is admitted to D, expansion takes place to E, when exhaust takes place and pressure falls to F, the exhaust passing at pressure F′ into the low-pressure cylinder, wherein the pressure is shown by the line F′ H, while the pressure in the high-pressure cylinder is shown by the line F G, and is higher than that in the low by the amount of the gap between them, the loss of pressure shown by the distance between the lines F G and F′ H being caused by friction through ports and passages and valves. At G the valve closes the high-pressure exhaust and compression takes place from G to B. In a

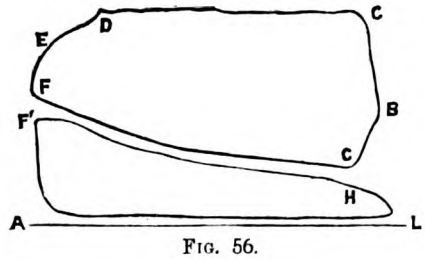

Fig. 56.

trial with the engine of this type, as above alluded to, the compound engine made 18,000 revolutions against a given brake load, the water being maintained at the same level in the boiler as shown by the water gauge, while the non-compound engine made but 15,000 revolutions, and the boiler lost an inch in the level of its water, the same weight of coal being used in both cases. The boiler would thus have been able to continue this rate of work with the compound engine, while the simple engine would soon have had to be stopped, or had some of its load removed to enable the boiler to overtake its water consumption. Moreover, the compound engine boiler was fed with cold water, while the simple engine had a feed heater which raised the water to 150 degrees.

AN IMPROVED REGISTERING APPARATUS FOR THE VELOCITY OF TRAINS.*

In railway travelling we are accustomed to arrive and depart punctually. If the train is delayed the traveller grumbles, unless the driver makes up for lost time by extra speed. He seldom thinks of the dangers that threaten a train going at a too high speed, and yet these are so great that every precaution must be taken to diminish them. There is no perfectly reliable means by which a too high speed may be avoided automatically, and thus the speed depends entirely on the will and attention of the engine driver. He has, indeed, precise directions concerning the allowed speed; but, since he cannot be mechanically hindered from overstepping his instructions, efforts have been made to at least subject their carrying out to exact regulation. This can be done in two ways, either by a self-registering measurer of velocity which is placed on the locomotive, or by means of contact apparatus placed on the railroad, and registering clocks which are set in action by the train itself.

On railroads which are provided with this registering arrangement there is an insulated wire stretched along the line, branching off to the contact apparatus, which, as a rule, are about a kilometre apart. If there is contact made in one of these apparatus, an electric current is sent to the station, and there the moment at which this current is sent is fixed by a registering clock and other appliances. Thus the speed of the train between any two contacts is known.

The contact apparatus usually consists of a set of one or more levers, which project from a box fastened to the track, and reach somewhat over the rail. When a train passes this place its wheels press down the lever, and thus produce the desired contact in the box.

The great difficulty has been to prevent these apparatus from being destroyed by the violent shocks to which they are subjected when a train meets them, but this has been greatly remedied by springs, with which the levers have since been provided. These contacts with springs have been found so useful that up to the end of 1885 more than 1,500 of them had been installed on the German railways.

Still, the contact apparatus with lever movement, despite all the care devoted to its construction, cannot be insured from external damage. Hence, for some time they have been trying to erect contact apparatus whose movable parts are hid, or more especially such as have no movable parts. They have fastened to the rails as contact makers little closed boxes which contain weighted springs, hammers, or quicksilver. When a train passes their inner mechanism is set in motion

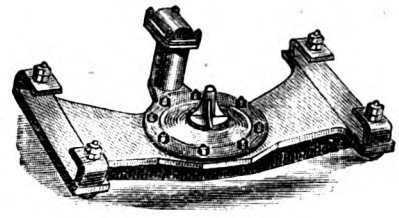

Fig. 1.

by the vibration of the rails, and makes contact by hitting against the corresponding conductors.

A third class of wheel-contacts depends on the bending of the rails against a fixed exterior point, caused by the passage of the train. All these apparatus have their several defects, and contacts are sometimes made without the passage of a train over the corresponding rail.

The firm of Siemens and Halske has lately produced a contact apparatus (Fig. 1), depending upon the bending of the rails, which needs no exterior fixed points, contains no movable lever, and can be made of any desired sensitiveness. That bending is employed which takes place between two points of a rail as soon as this is weighted between these points by a wheel of the train. The strong transfer of movement, which is necessary to insure results with certainty in such an apparatus, is obtained by hydraulic transference of pressure as follows:—

Under the rails a strong cast-iron bent beam $M L L_1 M_1$ (Fig. 2) is firmly screwed by means of the nuts $M M_1$. In the

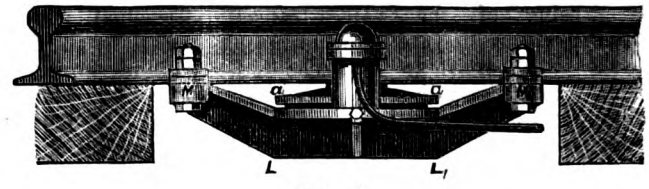

Fig. 2.

centre this beam forms a flat dish (Fig. 3), which is shut in by the spring-steel plate *b b*. On *b b* rests the iron disc *c c*, which is held centrically by the pressure of the plug *d*. The plug is so adjusted that it just touches the rail when the apparatus has been screwed to the latter. On the cover of the dish *a a*, and under the foot of the rail, there is a ring of gutta percha fixed to protect *d* from the penetrating sand which might impede its free action. The vessel G is in connection by the narrow hole and pipe *f f* with the hollow space under the plate *b b*. This pipe widens itself upwards into the cup *r*. As far as the tube projects into the cup it consists of insulating material; *f* communicates with the hollow part of the vessel by the little opening *h*, and there is also a small hole, *s*, in the bottom of the cup.

*From the *Elektrotechnische Zeitschrift* for April, 1886.

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The space under *b b* and the vessel G are so far filled with quicksilver that the bottom of the cup is just covered. From the difference of level of the quicksilver in G and under the plate *b b*, the plug *d* is always firmly pressed against the foot of the rail by a hydrostatic pressure of about 30 kilograms. If the rail bends a little by a weight passing over it the foot of the rail presses on the plug *d*, and the pressure is communicated by the disc and plate *b b* to the quicksilver, and it soon fills the cup *r*, since the surface of the plate is to the section of the tube as 600 to 1. As soon as the train has passed, the quicksilver runs slowly out of the cup through the hole *s* into the vessel, and thence through the hole *h* again into the space under the steel plate.

Into the bowl *r* and the insulated end of the tube *f* projects the fork *i*, which is connected to an insulated cable. This fork is insulated from the earth except when the mercury reaches it.

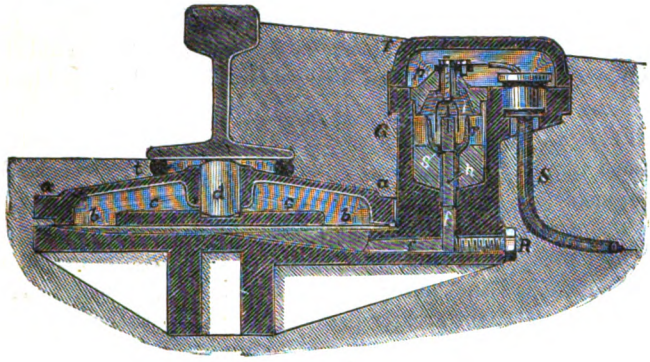

FIG. 3.

All the parts which come in contact with the quicksilver are made of iron, because this metal suffers no amalgamation.

Above the glass cover to which the fork is fixed there is a cast-iron lid, which covers the entrance of the cable and shuts off the whole from all air and damp.

This new railway contact apparatus is in many respects an advance on the former constructions. It is quite removed from external damage, in consequence of its position under the rails, where it is almost completely buried in the earth, and also on account of its solid construction. It also avoids an evil which easily arises with other contacts made by means of mercury, viz., that the quicksilver in course of time oxidises on the contact surface, and thus becomes covered with a badly conducting film, whence faulty contacts may arise; for with each passing train the little cup becomes full to overflowing, the quicksilver runs over the edge, and throws the lighter oxide into the vessel G, where it does no harm. Hence the mercury which rises out of the pipe *f f* and makes the contact is always clean and bright.

Since there are no movable parts there is no cost to keep the apparatus in working order.

ON THE POSSIBLE CONNECTION OF HALL'S PHENOMENON WITH THE ROTATION OF THE PLANE OF POLARISATION OF LIGHT.

BY MISS J. M. CHAMBERS, B.SC.

Suppose the current in the cross (Fig. 1), when there is no magnetic field to pass straight from A to B, so that no component passes along L R, and suppose a magnetic field to be made whose force lines come up from the paper towards the spectator (that is, the field produced by a current whose direction is represented by the curved arrow), then a small component of the current will pass towards R if the cross is of gold, &c., so long as the field lasts (*i.e.*, it is permanent, not merely a transitory current produced in accordance with Lenz's law). If the cross is of iron, &c., the current will pass towards L. In fact, there is a small rotation of the equi-potential lines, and, therefore, of the E.M.F., against the direction of rotation of the current producing the field if the substance is of the nature of gold, copper, or bismuth, and with the current, if it is magnetic, like iron, &c. This is precisely the same thing as what I suppose takes place in the molecules of a transparent substance when a rotation of the plane of polarisation of light occurs, except that the rotation is in the opposite direction (at least I so understand the descriptions of Hall's phenomenon, though there is some confusion). Perhaps the reversal of the direction of rotation might be accounted for by remembering that the internal force lines of the molecular circuits are of opposite sign to the external ones, and here we are not dealing with a molecular current.

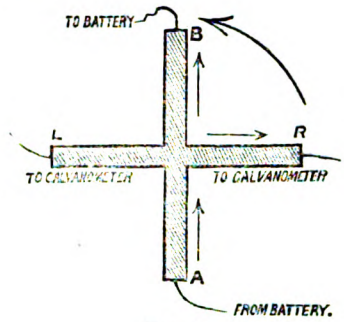

FIG. 1.

It may be noticed that, if we suppose the electrical vibration constituting light to take place outside instead of inside the molecules, the direction of rotation of the plane of polarisation is reversed, for the current A B is then (Fig. 2) attracted towards the left in its upward course and towards the right in its downward course.

But in the case of light we must suppose the ether which surrounds the molecules a more or less perfect insulator (since transparent substances are insulators), and then the vibrations will more likely take place inside than outside the molecules which we suppose infinitely conducting, or at least the motion of the electricity will be greater inside than outside. And we may suppose, if we please, that a vibration travels through several molecules, since molecules are probably very small in comparison with a vibration of light as they are in comparison with its wave-length. We may easily suppose that a vibration passes inside through the molecules, even if no electricity can pass in or out of them so that a *current* must pass outside them.

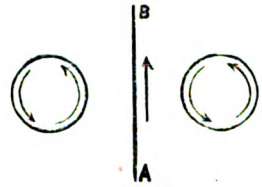

FIG. 2.

Viewed in this way Hall's phenomenon may be regarded as an action of the field on the current itself, when it fails to be able to move the conductor bearing it. Thus, as a north pole would be driven towards L (Fig. 1) by the current, the current is driven towards R by the north pole which gives the lines of the field.

Notwithstanding all this, however, the writer thinks that in the opinion of the majority of physicists, Hall's phenomenon cannot be thus explained; for the action thus explained should take place in all conductors whether thick or thin, while it is only in the very thinnest films of metal that any such effect has ever been observed. The phenomenon observed is probably a Peltier effect due to the strain on the conductor caused by the passage of the current in the strong magnetic field. (See papers by S. Bidwell, &c., *Phil. Mag.*, *Proc.* of the Royal Society, &c., 1884).

WEST COAST OF AMERICA TELEGRAPH COMPANY.—The gross earnings of this company for the month ending May 31st were £3,450.

SALE OF ELECTRICAL PLANT.—On Wednesday and Thursday, the 23rd and 24th inst., Messrs. Wheatley Kirk, Price and Goulty will sell by auction the surplus electrical plant, apparatus, and fittings of the Edison and Swan United Electric Light Company. Particulars will be found in our advertisement columns.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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MILITARY TELEGRAPHY.

"So important will be the part played by military telegraphy for Outpost and Vidette duty, that the army which has the most efficient system of electric signalling will hold a trump card which may exert a decisive influence on the game in any future European war." These words, spoken by a military authority of high standing at the last meeting of the Telegraph-Engineers, were intended partly as a compliment to CAPTAIN CARDEW, the ingenious inventor of the system then under discussion, but partly also as a justification for bringing the subject under public notice. We join in the compliment, but it would have been deserved all the same without the publicity; and in the quarter most concerned with the matter, appreciation will, or ought to be, none the more hearty for being endorsed at a public scientific meeting. CAPTAIN CARDEW stated that his apparatus and methods had been kept a secret for four or five years; but that, as something very like them were being evolved independently elsewhere and for a different purpose, he had sought and readily obtained permission to explain the whole business. Too readily we think; for if it is really a fact that these English military telegraph appliances were a secret, they might have remained so with advantage, notwithstanding that the principle on which they were worked was being applied in other directions. We cannot suppose that the WAR OFFICE is afflicted with the common human weakness of claiming priority of invention merely for the sake of getting credit for it. The true explanation probably is that the Department has acted on its traditional policy, which, according to prevalent rumour, lets everybody into its secrets except those who have the best right to know them. Within the last few days a complaint has been made that while the staff officers of the British Army are forbidden to obtain maps of our Indian frontier, Russian emissaries are granted free access to all existing maps as well as to the localities themselves. If representatives of every European country have not already taken full stock of CAPTAIN CARDEW'S secrets, it will apparently be no fault of the WAR OFFICE.

We give a brief account of the system elsewhere, the essential features of which, however, we do not propose to enlarge upon, or to criticise. If they are as valuable as we are told they are, our sincerest hope must be that every foreigner who inspects them will treat them with contempt. On one or two collateral points, however, connected with the subject of military telegraphy, we would offer a few observations. First of all it seems necessary to define what we mean by military telegraphy. For those duties referred to by MAJOR BERESFORD, whose words we quoted at the beginning of this article, a telegraph of any kind is strictly military. It must possess mobility as a very first essential; it must be light yet capable of rough usage; the working apparatus should be simple and permanent; and the whole should be capable of working under the most disadvantageous electrical conditions. CAPTAIN CARDEW'S arrangement seems to answer the two last named requirements extremely well; and we believe that the equipment of our Field Telegraphs has answered the first requirement in the severe tests to which it has been put in the African campaigns North and South. Probably no nation is better provided in these respects, certainly none with better signallers. But the greater part of the work hitherto done by this military arm has been of a non-military kind; and it was evident the other evening that neither CAPTAIN CARDEW nor his critics were particular in drawing distinction between what is needed for the working of a telegraph line in the public service and what for a flying column, or for scouts with a line intended solely for keeping telegraphic touch with the main body. The two things are not the same, and on occasions may be totally different. Conditions essential for the one may be disregarded in the other; and to aim at perfection for both would be fatal to one, and that the most vital of the two. It is no objection to the Theiler Sounder or Telephone that they are not good for the "Traffic" which trails in the rear of an advancing Army. What is needed for that kind of telegraphy is something a great deal too perfect, too delicate and too sensitive for a strictly military telegraph, which is always in front of the Army, and for which ruder and more temporary appliances are preferable.

If these two very dissimilar requirements are not confused, there is no great difficulty in satisfying the one that is purely military. Different countries have different preferences. Germany appears, for example, to prefer the recording Morse. If Germany is ever to be England's foe in the field, which God forbid, we hope that the preference may continue. It is said that the military authorities of that warlike nation have scouted the idea of adopting any instrument which is non-recording. We do not want to combat the prejudice; but as it seems to be shared to some extent in this country, we would venture to ask what is the peculiar value of any recording instrument that does not actually write the despatch which is delivered? We know of none that does. Printed tape, we may safely conjecture, is nowhere delivered to the commanding officer; and as regards the operator, the process of reading is every bit as safe from a sounder instrument as from a so-called "printer." Flag-signals make no record; the heliograph leaves no sign except in the memory of the reader. Yet both these methods of signalling in military operations are now of recognised, and in some cases of exclusive utility. During the Franco-Prussian war illustrated periodicals gave us pictures of the German Army Telegraph offices, with telegraphists comfortably seated at fitted tables, and all the paraphernalia

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nalia of paper-wheels, ink-writers and the rest; but nobody—nobody, at all events, but a German—would be so pedantic as to insist upon this cumbrous array of frail and troublesome gear forming part of every reconnoitering party's equipment. The apparatus is unsuited for transport; much delay must occur before it can be got ready for use, and the chances are that it will not work when it is wanted. None of these defects can be ascribed to the handy, effective, and trustworthy arrangement which CAPTAIN CARDEW has put the English War Authorities in possession of. We hope they will stick to it—with this reserve only, that if they secure any further improvement, or anything better to supersede it, they will keep the secret to themselves.

CORRESPONDENCE.

ANSWERS TO CORRESPONDENTS.

ELECTRIC BELLS.

If Mr. C. B. Callow will send samples and diagrams to *The Electrician* office, no doubt the editor will permit them being illustrated and published in a future number. At the same time, these articles are intended to assist amateurs in their work, and cannot describe every modification of any one article.

THE WRITER OF THE ARTICLES.

London, May 31st, 1886.

THE SOLDERING OF WIRES.

In reply to "An Amateur," the reason why spirits should not be used is because of the corrosion that takes place, which is quite sufficient to eat small wires quite asunder. The action is much hastened in damp situations.

THE WRITER OF THE ARTICLES.

London, May 31st, 1886.

KEEPING E CONSTANT AT A DISTANT POINT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Could any of your readers tell me what great advantages the "multiple main" system, used at Paddington, has *for the above purpose*, over a single main of the same sectional area, with adjustable resistances at one point in the circuit, except the rather dubious one of costing a good deal more?—Yours, &c., D.

London, June 1, 1886.

DIVIDED MAINS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the very interesting account you publish of the Paddington installation the writer introduces (p. 53) the Gordon divided main apparatus as being "considered the most important part of the system, for by its use the quantity of copper required in the feeding mains is reduced to one tenth of that used in the ordinary method." Nothing is said of the waste of energy consequent on this very economical reduction; my object in writing is, however, not to cavil at the dimensions of the mains as a whole, but at their divided state. Each component of a feeding main is practically a separate lead, and must be insulated from its neighbours, which insulation costs something. Why not use one solid main of the same area as the sum of the bundle of wires and introduce a variable resistance at the central station? There is the same loss from heating, but that loss is confined to one small space, and the inexhaustible ingenuity of the installation electricians would easily find means for utilising the heat given out in the rheostat. For example, it might be used to heat the feed water, or even cook a chop. It is true that this plan would relegate to the scrap heap all that indescribable conglomeration (Supplement, Fig. 1) of water-motor, governor, voltmeter and brake-block; but then the functions of this mysterious apparatus are already at a discount, for we read (page 53):—"Suppose a certain number of lamps are switched off, the pilot brightens a little, and calls the attention of *the attendant* to the voltmeter. He then moves the contact wheel, &c., and brings back the pressure to its normal value." Why that *attendant?* Is not the apparatus automatic?

There must be many of your readers beside myself who would like to see the complete theory of "divided mains," including such details as interest and depreciation on, and average power wasted in heating the mains, and the cost of a joule at Paddington.—Yours, &c., SYDNEY EVERSHED.

Kenley, Surrey, June 2, 1886.

RESEARCHES UPON THE SELF-INDUCTION OF AN ELECTRIC CURRENT.*

BY PROF. D. E. HUGHES, F.R.S.

Numerous researches have been made upon the self-induction of coils of wire, and but few in relation to the influence exerted by the nature and geometrical sectional form of the electrical conductor when employed in straight wires as in those of a telegraph line with the earth as a return, or those of a single wide loop where the distance of the return wire is sufficient to prevent any appreciable effect from the *mutual induction* of separate portions of the wire upon each other; our present theories class all non-magnetic metals together, taking only into account their specific resistance and the diameter of the wires; they admit, however, a certain modification in magnetic metals due to their magnetic permeability; but we have had but little experimental evidence of the effect produced.

The whole subject seemed to me worthy of experimental investigation, and I have lately† given the results of a first series of experiments made last year. I have remarked since writing that paper many new and important effects, and I have made a new series of researches, the results of which I wish particularly to point out in this paper. In my late researches I made use of a modified "Wheatstone bridge," together with a portion of my "induction balance," by means of which the induced or extra currents from the wire under observation were balanced by a secondary current induced from an independent circuit; this gave excellent results, but the method has been criticised as having the fault of not being clear in its indications. In order to meet this objection and also verify the results which I had previously obtained, I constructed an entirely new bridge, founded upon a most simple and well-known principle, and as the bridge admits of no change in the relative resistance of its sides its action can be easily understood; it is with this instrument that I have made my new series of experiments. The instrument consists of an ordinary Wheatstone bridge, with the exception that a telephone replaces the galvanometer; there are in addition two coils of insulated copper wire, one in each portion of two sides of the bridge, by means of which the mutual self-induction of its convolutions can be increased or decreased as desired. The electrical contacts are made either by a continuous periodic or turning fork contact maker, or by a peculiar clockwork rheotome which I have made, in which a contact spring rests lightly on a wheel whose roughened surface is divided into eight equal parts of contact and insulation, by means of which we receive on the telephone eight equal periods of sound and silence each revolution of the wheel. We are by this means better enabled to appreciate feeble sounds than if they were continuous, and as the wheel can be made to revolve at any between two and ten revolutions per second, we have from sixteen to eighty periods of silence between each rubbing contact per second.

Fig. 1 shows the theoretical plan of the electrical communications of the bridge.

A, B, C, D are the four sides of the bridge, the telephone J replacing the ordinary galvanometer; the sides C B and C D are formed of German silver wire, each 50 cm. in length, 0·5 mm. in diameter, and 0·85 ohm resistance; the sides A B and A D have also 0·85 ohm resistance, so that the four sides have equal resistance, and this remains a constant during the whole series of experiments. A E and A F is a continuous spiral of copper wire, formed of hard copper silk-covered wire of 1 mm. diameter and 4·80 metres in length, wound loosely on a boxwood cylinder of 3·50 cm. diameter and 30 cm. in length, on which it moves freely; the entire helix has 40 turns of 4 cm. diameter, each spiral being separated 5 cm. from each other; the spiral, however, is separated into two equal portions by giving a greater separation at the centre in order to allow it to be attached to a sliding collar of wood, by means of which we can press the spiral closer together on either side as

* Read at the Royal Society, May 27, 1886.

† "Self-induction of an Electric Current in relation to the Nature and Form of its Conductor." *Journal* of the Society of Telegraph-Engineers and Electricians, January 28, 1886.

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desired ; at E and F there are also adjustable collars of wood, and as the boxwood cylinder is graduated, we may (if the central collar is fixed) approach more or less either side of the helix, and read the degree of approximation of the coil, thus adjusting the mutual induction of each side to a perfect balance or zero. In practice I prefer moving the central collar, using the end collars only for the perfect adjustment of its zero, as we then have a double effect, viz., closing the coil, say, from A to F, increasing its mutual self-induction, and at the same time decreasing the previously balanced induction of the coil A E. This not only gives a wider range of effect, but renders the scale readings more uniform ; the end F of the helix is joined to about 10 cm. of German silver wire, completing the circuit from G to D. This supplementary German silver wire is simply for the purpose of making the resistance of AD equal to DC, and its length should be adjusted to this purpose ; the end of the helix E joins directly with the terminal N ; the wire to be tested X is joined to N and H ; from H to I there is a second supplementary German silver wire allowing us by means of the contact side M, which is in direct communication with B, to introduce more or less of the German silver wire in the side AB. The resistance of the wire to be tested should always be less than that of the opposite side of the bridge, and we then make up the total resistance of AB by sliding the contact slide M until the resistance of AB equals AD.

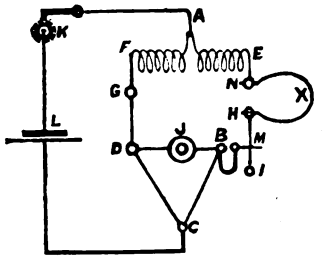

FIG. 1

It will be evident that in the whole series of experiments there can be no change in the resistance of either side whenever zero is found, the induction coils or balance having the same proportional current in all the changes of the wires under observation; the battery and telephone circuit present also a continuous absolute relation. We may, however, when desirable, keep the resistance from H to M a constant, and vary the resistance or the length of the German silver wire G D ; we then balance the wire X by an equal resistance on the opposite side of the bridge. But then the battery and telephone circuits no longer possess the invariable relations which are so extremely necessary in experiments of the nature of which I have been making. The battery circuit is joined in the usual manner to A C, the current can be interrupted by the rheotome K, or by means of a commutator (not shown in the diagram) close the battery circuit, and transfer the contact maker to the telephone circuit B D ; this allows us to observe the effect of an intermittent current compared with that of a constant or steady flow. M. Gaugain has termed the period of a steady flow of current the *stable period*, and that in which a rise or fall of the current takes place the *variable period* ; these terms have since been generally adopted by telegraph electricians, and in order to avoid introducing new terms they will be used in this paper.

It would require too much stace to enter into the details of the construction of the bridge ; special care is required in the construction of the balancing induction coils, and in securing perfect electrical contacts in all parts of the bridge. The induction balance requires calibration, and for this purpose I introduce as the wire X successive lengths of 10 cm. 1 mm. diameter copper wire, thus forming a table of values throughout the range of the induction balance, or by equal increments of 10 cm. of copper wire up to 20 metres. Having no unit of self-induction to which my results could be quickly and practically referred, I have adopted as unit the self-induction of a straight copper wire 1 mm. diam. and 1 metre in length ; this gives on my calibrated induction scale 100 degrees, and it is to this standard that all the comparative force of extra currents mentioned in this paper is compared. The self-induction of a wire is proportional to its length, consequently a source of error might exist in the different lengths of the supplementary resistance wire H I introduced to balance the resistance of G D ; but as we are enabled by the high specific resistance of German silver wire to obtain a very great change in resistance by a comparately small movement of the sliding scale, this error in most cases of comparative experiments is but a fraction of 1 per cent., and when taken into account, as it should be, the error no longer exists. The telephone used should be of the most perfect kind, and adjusted expressly for rapid and feeble sounds. I have found it best to employ an extremely soft Swedish iron diaphragm, without varnish or anything that can diminish or deaden the sound ; its fundamental note should be higher than those generally in use, or at least 500 double vibrations per second, for we have to deal with extremely rapid effects which on short wires cannot be rendered evident upon a galvanometer, but which with a telephone in perfect adjustment are heard most distinctly with an electromotive force in the battery circuit ranging from 0·001 to 0·250 ampere.

In the sketch of the communications the wire to be tested, X, is shown in the form of a wide loop, but in practice the instrument is constructed on two separate frames of wood articulated together at D, by means of which we can separate the terminals N H, and introduce straight wires, sheets, or tubes of lengths varying from 5 cm. to 1 metre. The object of my researches being to observe the self-induction which takes place in straight wires, or in those of a single wide loop where the reaction from any return wire is at such a distance that its influence is not appreciable, I shall, therefore, use the term self-induction to indicate the effects due to the electric current in its own portion of the wire, and mutual induction to those where the reactions of different portions of the current and circuit react on each other, as in the case of coils ; and although some theoreticians consider the two cases as the same, they are, as my experiments prove entirely distinct, for we have, as will be shown, for copper wires a low coefficient of self-induction with a high mutual induction, whilst in iron wires the reverse is the case, for we there have a high coefficient of self-induction with an extremely feeble coefficient of mutual induction.

Influence of the Nature of the Conductor upon its Self-induction.

I found, as shown in my late paper, that there was a marked difference in the specific inductive capacity of iron and copper, and this entirely agrees with well-known theories ; but I suspected that there might be some difference in the non-magnetic metals independent of their specific resistance. For this purpose I made a series of experiments with wires of the same length and diameter, but of different resistance. These showed a marked difference provided the current was increased in proportion to its diameter or conductivity, but no difference could be found when the current was kept a constant, and the interior differences in resistance of the wires were compensated by an external added resistance ; but if we take wires of different metals—all of the same length and resistance, but of different diameters—there is a marked difference due to the mutual reactions of the current in its own wire, being less in wire of large diameter than in small wires. These effects have been fully explained in my late paper, and have since been completely verified by the method used at present. I showed by the use of my late method a critical point in the rise and fall of the induced currents. This is not shown by the present method of compensating by external resistance, but the rapid decrease in the electromotive force of the induced currents, as indicated by the induction balance, is well shown by the present method. The following table shows the observed force of the extra currents for wires of the same length (1 metre), but of different diameters :—

—	mm. 0·25	mm. 0·50	mm. 1·00	mm. 2·00	mm. 3·00	mm. 4·00	mm. 5·00	mm. 6·00	mm. 7·00	mm. 8·00	mm. 9·00	mm. 10·00
Iron	760	621	530	360	269	220	190	171	152	138	128	124
Copper ...	129	113	100	89	82	78	75	73	72	71·5	71·2	71

The fall in force is now even more rapid than shown by my late method, and it will be seen that iron is peculiarly sensitive to an increase in diameter, having nearly six times the force of copper in wires of 0·25 mm., and not twice the force of copper in wires of 10 mm. section.

Reactions of an Electric Current in its own Portion of Conductor.

The phenomenon of a constant decrease in the electromotive force of self-induction, as measured by the induction balance, with each increase of the sectional area of the conductor, is well shown by the present method, and an experimental investigation of its cause has shown that we should not consider a current in a wire as a single element reacting solely upon exterior wires, but that the current acts precisely similar as would an infinite number of independent streamlets of current reacting upon each other in the interior of its own wire similar to their known effects upon exterior wires. My experiments demonstrate this to a degree that leaves no doubt on my mind as to its truth, for according to this view we should be able to reduce the self-induction to a very great extent by employing thin flat sheets where the outlying portions are at a comparatively great distance from the central portions. This I have experimentally proved to be the fact, but this experiment alone does not show if the reduction of self-induction is due to a different arrangement of the current in sheets as compared with solids. If the reduction is due to the greater separation of the streamlets, then we should be able to reduce this induction in a still greater degree by employing a conductor composed of numerous small copper wires through which the current is equally

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divided, and which could be separated or brought close together as desired. This proves to be also an experimental fact, for the conductor formed of numerous strands has far less self-induction than a thin sheet when its wires are separated, so that they can no longer react on each other, and surpasses the thin sheet and approaches the value of a circular wire when these wires are brought near together, so that their mutual reactions can approximate those of the numerous streamlets in a solid conductor.

Iron shows a still greater reduction in its self-induction when in the form of thin flat sheets or numerous small iron wires separated from each other, with the exception that we cannot restore or approach the value of a solid wire by bringing them in close proximity. The reduction of the induced currents by employing thin sheets instead of a wire is so great in iron that we could not account for it on the mere separation of contiguous portions of the same current, but if we assume that the comparatively high force in iron wires is due to the induced circular magnetism, and that this almost disappears in flat sheets, we account for the fact that a thin flat sheet of iron has less inductive capacity than a similar sheet of copper of the same resistance, but of different widths; and if thin strips of copper, brass, lead, and German silver are compared with similar iron strips, and their resistance rendered equal by the added resistance in the bridge, no difference is found between iron and the non-magnetic metals, for under these conditions their inductive capacities appear equal.

(To be continued.)

THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

At the concluding meeting of the summer session of this society, held at Great George-street, Westminster, on 27th May, Prof. Hughes, F.R.S., president, in the chair, Captain P. CARDEW, R.E., read a paper "On the Telephone as a Receiving Instrument in Military Telegraphy." After some preliminary observations Captain Cardew said:

The system I am about to describe, which was invented by me five years ago, has been kept secret by us hitherto, but as something very like it has been applied to communication with moving trains, and as it is certainly well understood by the principal makers of apparatus, I have without difficulty obtained permission to describe it and the experiments made with it. This will perhaps be best done by detailing the steps by which it was reached. Shortly after we became possessed, at Chatham, of any really well-made telephones, the idea of using them as receiving instruments for telegraph messages sent by the ordinary Morse code struck Major Armstrong, who was then in charge of the Electrical School, as probably applicable to field telegraphy, where interference from induction from parallel wires was not to be apprehended, and where the extreme sensitiveness of the instrument would probably enable work to be carried on in spite of faults of insulation, hasty joints, bad earth connections, &c. This idea was worked at for some time. It was found that there was some difficulty in reading, due to the almost perfect similarity of the make and break clicks in the telephone and the consequent liability to read the signals reversed. Still, this was probably to be overcome by practice, and eventually it was determined to try through what length of bare wire laid on the ground without any insulation the method would admit of carrying on work. Some experiments had also been carried out at this time with some vibrating sounders sent for trial by Messrs. Theiler.

These consisted of simple electro-magnets, the armatures being attached to a piece of German silver spring, fixed at both ends, and with a contact screw arranged so that when the armature was attracted it broke the current through the coils; in fact, just on the same principle as an ordinary chattering bell, but arranged to give a musical note. They were intended to be used as ordinary sounders, but the difficulty was, that they interfered with each other if more than two were used on one circuit.

The following is an extract from a report I made to the Royal Engineer Committee on the experiments carried out with this bare wire:—

Report on an equipment with 15 miles of bare wire laid on the ground, with a view to ascertain the possibility of signalling through it by means of telephones.

Telegraph School,
School of Military Engineering, April, 1881.

The wire consisted of 10 miles of No. 16 B.W.G. soft iron galvanised wire, and 5 miles of No. 16 B.W.G. copper wire. This arrangement possessed the disadvantage of keeping a continuous current on the line from the earth contact of the two wires, and of tending to destroy the iron wire, but, as the line was only required for a short time, this was not material.

Permission was obtained from the authorities of the London, Chatham, and Dover Railway, to lay the wire at the side of their line of rails. It was consequently laid in a loop extending from a short distance on the up side of the New Brompton Station to within a short distance of Newington Station, and back again on the other side of the line.

To ensure the wire being well out of the way of the traffic, it was laid in the *hedges* in many places. In other places it was laid on the ground, even picketed down under stiles so as to prevent its tripping people up. The ground was generally newly made or garden ground, and the soil of fair conductivity. Rather more than half the wire was thus laid in the hedges. At road crossings the wire was stretched over a pole at each side. For convenience, one end of the wire was brought into the Royal Engineers' Institute. This necessitated using poles to avoid interference with traffic, and for convenience some poles carrying existing lines were made use of. This introduced induction signals, so that, in getting signals through, the following difficulties had to be contended with, viz.: 1. Very bad insulation. 2. Continuous current from the different metals in the line wires and earths employed. 3. Induction currents confusing signals. The line resistance was never accurately obtained, this being impossible under the conditions, but it must have been about 900 ohms, while the insulation test from the institute gave on several days a resistance as low as 300 ohms, which of course included part of the line resistance, the position of the resultant fault being at any rate some distance beyond the end of the insulated wire, so that the true insulation resistance must have been extremely low. The first intention was to use the telephones as Morse instruments, with an ordinary key as before proposed, the connection being the same as for a sounder or Morse.

This was tried with batteries of 10 Leclanché cells at each end. At the institute, in a quiet room, there was no difficulty in reading these signals, but the ear had to be kept quite close to the instrument. At the other end there was some difficulty in reading signals when first tried, owing to a very high wind producing noises in the telephone. To get over this I tried the effect of putting on a Theiler sounder, sending a vibratory current out to line."

This was completely successful, the note produced being very easily read, and quite distinct from the induction signals, and the noises due to earth currents.

Signalling was carried on for several days by this method without any difficulty, clearly demonstrating that by this means signalling can be kept up through bare wire laid on the ground (as rapidly as cable), and afterwards poled and insulated when circumstances permit.

Another advantage of this use of the telephone is, that no adjustment of the receiving instrument is ever necessary, thus eliminating a fruitful source of delay.

For ordinary insulated lines the battery power required is very small, and the telephones are ready when necessary to be used in the ordinary way, and would no doubt be found very useful by the General and his staff as a means of personally communicating orders.

Another and preferable method of connecting the Theiler Sounder is so arranged that:—1. The current through the Theiler sounder is practically uninfluenced by any change occurring in the line resistance. 2. In the case of a dirty back contact in the key (a fault of frequent occurrence causing much delay), continuity will still be established through the coils of the Theiler Sounder. 3 Fewer cells can be employed (four cells Leclanché being quite sufficient for ordinary circuits).

The note given by the Theiler sounder in the telephone is quite as loud as the tone of the ordinary sounder under ordinary circumstances. When working through bare wire laid on the ground it is of course low, but still quite distinct if held close to the ear.

A simple apparatus for holding the telephone in the required position, so as to leave the arms free, could be easily designed. Two telephones, one to each ear, might then be advantageously employed.

From the results of this experiment with bare wire, I feel confident in recommending the employment of this combination of Theiler sounder and telephone in place of the ordinary sounder for field service, over which it possesses the following advantages:—

1. The possibility, as demonstrated, of working through a considerable length of bare wire.
2. The receiving instrument requiring no adjustment for altered conditions of line and different stations, &c.
3. The reduction of the battery power required to be carried to at most one-fourth of the present requirements.
4. The continuity of the line being ensured, independently of the back contact of the key.
5. The power of working through very bad earths, saving much time in very dry places.
6. That the note signals are more easily read than the interval signals by men untrained to either.

Experiments were immediately afterwards carried out by the field telegraph troop at Aldershot with this system, which was reported on very favourably by Colonel (then Major) Hamilton, R.E, commanding the troop, from whose report I need only extract the following paragraph:—

"I should add to the above, that the experiment was tried of poling the line which had been laid on the ground while messages were being sent through the line, and the poling did not in the least interfere with the reading of the messages. It therefore follows that a line of bare wire may be laid as fast as an army advances, and that a party may follow slowly and pole the line; the communication being established from the first laying out of the line."

An extensive trial of the system was in consequence approved. Rather unfortunately, in order to save expense, it was proposed to convert the existing old pattern field sounders into Theiler or vibrating sounders.

Some of these converted instruments and telephones were taken out to the first Egyptian Expedition in 1882; and this system was used exclusively in sending the messages from the field of Tel-el-Kebir from 8:30 a.m. to 6 p.m.

A new pattern of vibrator was, however, then considered essential, and this was the pattern designed. [Shown.] As the noise made by the vibrator and the telephone at the sending end was sometimes a nuisance, it was reduced to a minimum in this instrument by using a very light armature—simply a piece of ferrotype or tinned iron—and by means of a small key at the side of the signalling key which, when depressed by one finger, short-circuited the telephone.

It was considered desirable to practically determine, if possible, the limit of distance to which the system was workable on a long aerial line isolated from other wires. As this could not be obtained in England the

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Indian Government was asked to try the experiment, and the following is an extract from the report of the Electrician of the Government Telegraph Department:—

"Weather clear and fine.

"Worked Tuticorin, a distance of 375 miles, by wire from Calicut, with 30 Minotto cells, reducing battery subsequently to four cells. Signals from Tuticorin very clear, and could, with the stronger current, be read on telephone held at some distance from the ear; but with the weaker current it was necessary to hold the telephone pressed against the ear.

"The thick, or No. 1, armature, was used at both ends throughout.

"The two parallel wires to Beypore (9 miles), and Malapuram (18 miles), also line to Vayitri and Tellicherry, were working at the same time, and all together during the above experiments, the two latter being suspended on same posts as the others, for a distance of ten yards from the office only.

"The beats from the offices working as usual were distinctly audible in the telephone, but, except when the weaker battery of four cells was on, the signals from Tuticorin on the vibrator were not interfered with—the musical note riding above the induction beats."

This clearly shows that, with an isolated aërial line, very great distances could be worked by this system without translation.

In 1883 some experiments on General Post Office wires were made with this system, of which the following is a condensed report:—

"1*st Experiment.*—New Cross to Chatham (30 miles), worked easily with one cell, and very good signals with six cells; also worked through wet string and human bodies.

"2*nd Experiment.*—New Cross to Bristol, 123 miles on poles and eight underground. Chatham to Bristol. 158 on poles and 10 underground—wires on the same poles—could hardly be got through with 60 cells.

"Ordinary apparatus worked with 30 cells.

"The vibration currents were destroyed by induction, especially in the underground part through London.

"4*th Experiment.*—Two parallel wires between New Cross and Chatham, fitted with ordinary ink-writers, also between the two vibrators and condensers, as in diagram."

This was an idea of mine to get an independent vibration-circuit superposed on ordinary working, and was quite successful, all three circuits working quite independently. Signals audible with 2 and good with 10 cells on vibrators, 30 on the Morse.

In place of the condensers an ordinary plate lightning protector was fitted, and afterwards a resistance of 10,000 ohms, without interrupting the working.

In commenting on these and subsequent experiments on 1st October, 1883, I remarked: "It is worth consideration, whether the system of working tried successfully in Experiment 4 could not be usefully adopted in the postal telegraphs. . . . The method is much improved by the addition of magnets on the Morse circuit, as the Morse clicks can be practically softened off in the telephone to such an extent, by being passed through the coils of a magnet, as to avoid all interference with the vibration signals."

Immediately after this I tried the effect of working with the addition of an electro-magnetic coil of considerable inductive power, on each end of the line, between the Morse instruments and the vibrators, and found it work perfectly.

This method was soon afterwards tried between New Cross and Chatham, and worked perfectly, although the condition of the line was so bad and variable that we could not succeed in duplexing the Morse. By this method, therefore, two independent circuits can be at once established on a single wire with single instruments, without any balancing or nice adjustments.

In order to simplify the connections for field purposes, I obtained some ½ M.F. condensers and magnet coils and fixed them inside a small box with three terminals outside, marked M. L. & V.—the coil being attached to M. & L., and the condenser to L. & V.

The boxes were then filled up solid with white paraffin, and the ends secured. They were, I think, about 9in. by 4 by 3, or perhaps less. The iron cores of the magnets were joined at both ends to form a complete magnetic circuit. To these boxes I gave the name of "Separators."

The instructions were simple:—"Join the Morse to M, the line to L, and the vibrator to V, and fire away." Of course it it evident that this separator system is practically the same as Van Rysselberghe's, but it was brought out quite independently, and in the manner detailed; and the fact that he can successfully employ it with the weak speaking currents shows how certainly it must work with the far more powerful vibration currents.

Quite recently an account has appeared in the papers of a somewhat similar system brought out by Mr. Edison, and marked with his usual ingenuity. No doubt it will be taken up now that the prophet belongs to another country.

Although the separators were not tried either in Bechuanaland or Egypt, the vibration system was found very useful, notably in one case in Egypt, where working was carried on for six weeks through a bare wire laid on the ground for a distance of 23½ miles, from Kaibar to Abu Fatmeh, and absolutely buried for a distance of 200 yards through the camp at Kaibar. This distance is rather longer than that worked through in England, viz., from Chatham to Faversham; but it was not really so severe a case, as the ground in the Soudan was decidedly dry, and that in England distinctly wet. The most noteworthy feature of this trial is that only two small Leclanché cells were used at either end, and that with this small battery power, through a line making dead earth all the way, the call signal was audible, even without holding the telephone to the ear.

The vibration system is now applied by us in many ways. For instance, with ordinary telephones a buzzing armature is fixed to the induction coil, causing a vibratory current in the primary circuit, which is reproduced as a call signal in the telephone, thus dispensing with the ordinary bell. The note is loud enough to be heard in an adjoining one.

I have also adapted it to an instrument for testing lightning conductors. [Instrument explained.]

The last instrument I submit to-night is a "Combination Box," adapted for speaking or telegraphing:—

The vibrating transmitter is double wound and acts as an induction coil for the transmission of speech. The microphone transmitter used is a "Hunnings" or "Moseley," arranged with a handle which forms a switch. This solution of the switch difficulty, which gave us some trouble, is due to Quartermaster-Sergeant Kenney, R.E., and is certainly the most efficient we have yet tried. It performs two offices: when speaking, it is squeezed in the hand, and completes the circuit through the microphone and primary coil; when listening the pressure is relaxed, the battery circuit is broken, and the secondary coil short-circuited. Thus the battery circuit is never kept on longer than is absolutely necessary, a most important point in the field, where small patterns of cells must be used and renewals may not be at hand.

In the discussion which followed, Major Beresford said that in any future European war the army whose vidette and outpost service was equipped with efficient telegraphic appliance would possess a trump card of enormous value; and that the system described by Captain Cardew had the great advantage of working satisfactorily under the most seeming disadvantageous conditions, besides enlarging the capacity of the single wire by means of the "separator." Mr. Von Treuenfeld was anxious to have an authoritative opinion as to the admissibility of non-recording instruments in active service. The German military authorities would not listen to any proposal which involved the use of an instrument that made no record of the signals Mr. Donovan on this remarked that throughout the American civil war non-recording sounder instruments were employed. After some little further discussion, Captain Cardew briefly replied.

Captain R. H. Sankey, R.E., then read a paper on "A Problem Relating to the Economical Electrolytic Deposition of Copper."

At the beginning of last winter I was asked by Mr. W. Goolden (of the firm of Goolden and Trotter) to assist him in a scheme for depositing copper on a large scale, and in discussing the question the following problem presented itself:—

Let it be assumed that an installation for the electrolytic deposition of copper consists of a number of depositing tanks, each containing the same cathode area and supplied with current by one dynamo, whose activity is given. Find what number of tanks, what cathode area per tank, and what density of current per square foot of cathode should be adopted, and in what manner the tanks should be electrically connected in order that the copper may be deposited at a minimum cost.

This problem, although of considerable practical importance, does not appear to have been attempted, at any rate in a theoretical manner. It is a somewhat complicated problem, and the following does not pretend to be more than a preliminary and approximate solution, though probably sufficiently accurate for practical purposes.

In the first instance the tanks will be supposed to be arranged in simple series.

Let

n = number of tanks;

S = surface of cathode per tank, expressed in square feet;

γ = density of current per square foot of cathode;

r = tank resistance per square foot of cathode;

ε = counter electromotive force of each tank;

then

γS = current flowing through each tank;

$\frac{r}{S}$ = resistance of each tank (not including leads);

and therefore the energy absorbed by *one* tank is

$$\frac{r}{S}\gamma^2 S^2 + \varepsilon\gamma S,$$

and the energy absorbed by all the tanks is

$$n\left(\frac{r}{S}\gamma^2 S^2 + \varepsilon\gamma S\right).$$

The energy absorbed by the leads only remains now to be accounted for. Whatever the number and size of the tanks, this portion of the energy can, by arranging the leads, be made equal to any desired proportion of the total energy expended in the circuit. A suitable assumption would therefore appear to be to make the loss of energy in the leads constant, in which case it can be expressed by $\alpha C V$, α being a constant to be afterwards determined.

Hence, from the conditions of the problem

$$n(r\gamma^2 S + \varepsilon\gamma S) = (1-\alpha) C V \quad . \quad . \quad . \quad . \quad . \quad (1),$$

which is the equation of energy.

Now, the cost of depositing *one* lb. of copper is

$$= \frac{\text{daily cost of all the tanks} + \text{daily cost of activity} + \text{daily cost of superintendence, \&c.,}}{\text{weight of copper deposited per diem,}}$$

and it is required to find what values of n, γ, and S make this expression a minimum.

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The first step is to find expressions for the various items of expenditure, and for the weight of copper deposited.

Daily Cost of all the Tanks.—This item will clearly be n times the daily cost of *one* tank, which it is found can be expressed by

$$k + k_1 S + k_2 S^2 + k_3 S^3$$

where k, k_1, k_2, and k_3 are constants as regards any particular installation. This expression will be denoted by $\phi(S)$.

The factors k, k_1, k_2, and k_3 depend on the design adopted for the tanks, on the amount of floor space provided, on the style of building, on the leads, on the maintenance expenses, &c. The following table gives in detail the various heads of expenditure, both as regards first cost, maintenance, and working expenses, and the above factors have been worked out for an average case. Although the *actual* values of these factors will vary, according to the circumstances of each installation, the *relative* values will not, it is thought, be materially altered.

Daily Cost of Activity.—The daily cost of activity, which will be expressed by A, depends on the size of the installation, on the class of boiler, engine, and dynamo used, on whether water power is available, on the number of hours worked per diem, &c. Under this head must also be included the cost of the apparatus required to keep the solution in motion. The daily cost of activity depends to a certain extent on the commercial efficiency of the dynamo; and in so far as this efficiency depends on the strength of the current, this item of expenditure will vary. But the variation, if any, is small, so that remembering that the watts are constant it can be assumed that the cost of activity is constant.

Daily Cost of Superintendence.—This item depends principally on the size of the installation, and can be regarded as constant for any particular installation; it will be expressed by B, and is taken to include all general expenses.

Weight of Copper Deposited.—It is known that one ampere will deposit $\frac{1}{384}$ lb. of copper per hour, so that the weight of copper deposited in each tank per hour is

$$\frac{\gamma S}{384}$$

and therefore, if work is carried on for T hours per diem, the total weight of copper deposited in the n tanks per diem will be

$$\frac{n \gamma S}{384} . T$$

Hence, finally, if U is the cost of depositing *one* lb. of copper

$$U = \frac{384}{T} \cdot \frac{n\phi(S) + A + B}{n \gamma S} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

This equation, combined with equation (1) and differentiated in the usual way to obtain a minimum value, gives, after some reduction,

$$S\left(\frac{r}{r + \frac{\epsilon}{\gamma}}(A+B) - n\phi(S)\right) D\gamma + n\gamma\left(S\,\phi^1(S) - \phi(S)\right) DS = o;$$

and equating the co-efficients of $D\gamma$ and DS to zero,

$$n = \frac{r}{r + \frac{\epsilon}{\gamma}} \cdot \frac{A + B}{\phi(S)} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

and

$$S = \frac{\phi(S)}{\phi^1(S)} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4),$$

and the values of n, γ, and S, which satisfy equations (1), (3), and (4), are those which make U a minimum.

A complete solution would be too complicated for practical use, but an approximate solution can be obtained, as follows:—

For equation (3) the following average values can be assigned:

$$r = 0{\cdot}15 \text{ ohm},$$
$$\epsilon = 0{\cdot}02 \text{ volt},$$

and, as it unlikely that γ will be less than 3 amperes per square foot, so that in practice the smallest value of $\frac{r}{r + \frac{\epsilon}{\gamma}}$ is, under these conditions, 0·96.

Therefore, as a first approximation,

$$n_1 = \frac{A + B}{\phi(S)} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5);$$

or,

$$n_1 = \frac{\text{daily cost of activity} + \text{daily cost of superintendence, \&c.,}}{\text{daily cost of one tank.}}$$

Returning to equation (4) and substituting for $\phi(S)$ and $\phi^1(S)$ their values, namely,

$$\phi(S) = k + k_1 S + k_2 S^2 + k_3 S^3$$

and

$$\phi^1(S) = k_1 + 2k_2 S + 3k_3 S^2,$$

it will be found that

$$k_2 S^2 + 2k_3 S^3 = k.$$

TABLE SHOWING COST OF DEPOSITING TANKS.

Items of Expenditure.	k	k_1	k_2	k_3	Cost when S=100.	Cost when S=1,000.
					Pence.	Pence.
Framework*	160	$\frac{390}{100}$	$\frac{5}{100^2}$	...	545	3,560
Lining	136	$\frac{200}{100}$	...	...	336	2,136
Apparatus for moving solution	60	$\frac{100}{100}$	...	...	160	1,060
Arrangement for keeping plates separate	...	$\frac{150}{100}$	...	...	150	1,500
Anodes	...	$\frac{4000}{100}$	...	...	4,000	40,000
Solution	...	$\frac{960}{100}$	...	...	960	9,600
Leads	...	$\frac{120}{100}$	$\frac{320}{100^2}$	$\frac{23}{100^3}$	463	56,200
Connections of leads to plates...	...	$\frac{240}{100}$	...	...	240	2,400
Switch	...	$\frac{500}{100}$	$\frac{23}{100^2}$	$\frac{0{\cdot}5}{100^3}$	477	3,200
Fitting up	...	$\frac{120}{100}$	$\frac{1}{100^2}$	...	121	1,300
Building	564	$\frac{1260}{100}$	$\frac{0{\cdot}6}{100^2}$	...	1,824	13,104
Total	920	$\frac{8040}{100}$	$\frac{291{\cdot}4}{100^2}$	$\frac{23{\cdot}5}{100^3}$		
Say 10% for interest and depreciation	92	$\frac{804}{100}$	$\frac{29{\cdot}1}{100^2}$	$\frac{2{\cdot}35}{100^3}$		
Divide by 310 working days, for daily cost ...	0·3	$\frac{2{\cdot}6}{100}$	$\frac{0{\cdot}094}{100^2}$	$\frac{0{\cdot}0076}{100^3}$	3·0	43·3
Working expenses, including rent, insurance, &c....	...	$\frac{3{\cdot}5}{100}$	...	...	3·5	35·0
Total	0·3	$\frac{6{\cdot}1}{100}$	$\frac{0{\cdot}094}{100^2}$	$\frac{0{\cdot}0076}{100^3}$	6·5	78·3
	k	k_1	k_2	k_3	$\phi(100)$	$\phi(1{,}000)$

* Supposed to be made of wood. Size, when S = 100, 5′ 0″ × 2′ 6″ × 3′ 0″.

For instance, taking the values of k, k_2, and k_3 given in Table I., it will be found that

$$S = 160 \text{ sq. ft.}$$

It will be observed that the value of S, which makes U a minimum, is dependent only on the factors k, k_2, and k_3, and is independent of the factor k_1, and also of n, γ, and C V. It follows that the size of the tanks in which copper can be deposited at a minimum cost is independent of the size of the installation, and depends only on the design adopted for the tanks, and on the proportion of energy wasted in the leads.

Within certain limits, however, the value of S has but little influence on the value of U, as will now be shown.

In equation (1) the term $n \epsilon \gamma S$ is comparatively small, as will be seen on referring to the values previously given for r, ϵ, and γ, and therefore

$$n r \gamma^2 S = (1 - a) C V \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

Combining this equation with equations (2) and (5), and reducing, it will be found that, *approximately*,

$$U = \frac{768}{T}\left(\frac{(A+B)\,r}{(1-a)\,C\,V} \cdot \frac{\phi(S)}{S}\right)^{\frac{1}{2}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

$$= \frac{768}{T}\left(\frac{(A+B)\,r}{(1-a)\,C\,V}\right)^{\frac{1}{2}} \cdot \left(\frac{k}{S} + k_1 + k_2 S + k_3 S^2\right)^{\frac{1}{2}}$$

Now, having regard to the values of k, k_1, k_2, and k_3, given in Table I., it will be seen that for small values of S, U is large, and at first, as S increases U diminishes, but that when S lies between certain limits the value of U alters very little—beyond the upper limit U increases gradually as S increases. This result is clearly shown by the curve in Fig. 1, and it will be seen that from S = 160 to S = 100, and from S = 160 to S = 250, the value of U only increases 1 per cent.

Further, if the values of k, k_2, k_3 were doubled, k_1 remaining constant, the corresponding limits for S would be 105 and 240 square feet; and if k, k_2, and k_3 were halved, the limits would be 65 and 360 square feet.

Making, therefore, every allowance for inaccuracies in the estimates, by means of which the values of the factors k, k_1, k_2, and k_3 were obtained, and for the effect of various designs and circumstances (and it is to be observed that these limits of S depend on the *relative* values of the factors and not on their absolute values), it would appear that any value of S lying between the limits of 100 and 250 square feet can be chosen without practically increasing the cost of depositing from the absolute minimum.

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Having therefore selected some suitable values for S lying between the above limits, the daily cost of *one* tank (*i.e.* ϕ (S)) can be found, and to do this it is unnecessary to find k, k_1, k_2, k_3, but an ordinary estimate of the cost is all that is required. n_1 can then be obtained from equation (5) and then γ_1, with sufficient approximation, from equation (6). Substituting in equation (3) the value of n is obtained, and then a more accurate value for γ. It is assumed, of course, that A, B, r, and ϵ are known.

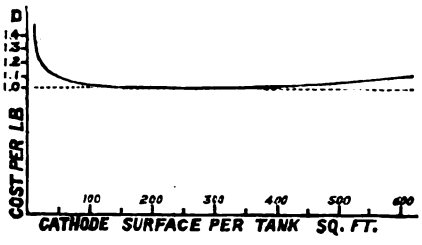

FIG. 1.

So far it has been assumed that the tanks are arranged in simple series; it remains to be seen whether anything is gained, or otherwise, by grouping a number of the tanks in parallel and placing these groups in series.

Electrically, each group can be looked upon as if it were *one* tank, having a cathode surface equal to the sum of the cathode areas of all the tanks in the group. Thus, if there be m tanks in each group, each tank having a cathode surface of S square feet, each group can be regarded as *one* tank having a cathode surface of m S square feet; and, if the additional leads required to connect the groups together are for the moment neglected, it is clear that the daily cost of the group will be $m\ \phi$ (S). Hence, applying equation (7)

$$U = \frac{768}{T}\left\{\frac{(A+B)r}{(1-a)CV}\cdot\frac{m\,\phi\,(S)}{m\,S}\right\}^{\frac{1}{2}}$$

r, with the proviso relative to the leads, the cost is the same as if the tanks were placed in series. But the additional leads required to connect the groups will cause additional expense by the energy wasted in them, and by the increased first cost.

On the whole, therefore, grouping the tanks is not so economical as placing them simply in series. Grouping the tanks entails also the disadvantages of requiring larger currents in the mains, and a greater difficulty in regulating the current per tank.

It remains to be found what proportion of the energy should be wasted in the leads and connections—in other words, what value should be given to the factor a. Following Sir W. Thomson's rule, the leads should be so proportioned that the cost of the energy expended is equal to the interest on first cost and the depreciation. The value of a depends, therefore, on the circumstances of each installation. For example, taking S = 100 and γ = 5 CV = 24,000 watts and A = 350 pence as an average case, it is found that

$$a_1 = \frac{1}{40}$$

and the sectional area of the leads would be about 2 square inches. The leads connecting the dynamo to the tanks were taken into account in finding the above value of a_1, but no allowance was made for switches and connections; adding about one fourth for this purpose

$$a = \frac{1}{30}.$$

The results arrived at are tabulated below, and it is hoped they may be of practical use.

1. The tanks should be arranged in simple series.

2. The cathode surface per tank for minimum cost of deposition is independent of CV, and can be selected between the limits of 100 and 250 square feet.

3. The number of tanks for minimum cost of deposition can be obtained from

1st approximation,

$$n_1 = \frac{\text{daily cost of activity} + \text{daily cost of superintendence, \&c.,}}{\text{daily cost of one tank.}}$$

2nd approximation,

$$n = \frac{r}{r + \frac{\epsilon}{\gamma}}\,n_1$$

4. The density of current can then be found approximately from

1st approximation,

$$\gamma_1 = \sqrt{\frac{(1-a)\,CV}{n_1\,r\,S}}.$$

2nd approximation

$$\gamma = \sqrt{\frac{(1-a)\,CV}{n\,r\,S} - \frac{\epsilon\,\gamma_1}{r}}.$$

5. The cost of depositing *one* lb. of copper can be found (approximately) from

$$U_{(\text{min.})} = \frac{768}{T}\left(\frac{(A+B)\,r}{(1-a)\,CV}\cdot\frac{\phi\,S}{S}\right)^{\frac{1}{2}}$$

6. The elements for winding the dynamo can then be found, since CV is given and $C = \gamma S$ is known.

The following numerical examples are appended as illustrations:—

Example No. 1.

Let CV = 24,000 watts, S = 100 sq. ft., ϕ (S) = 6·5 pence, A = 360 pence, B = 50 pence, r = 0·15 ohm., ϵ = 0·02 volt, $a = \frac{1}{36}$, working 10 hours a day;

then
$$n_1 = \frac{360+50}{6\cdot5} = 63$$

$$\gamma_1 = \sqrt{\frac{(1-\frac{1}{36})\,24{,}000}{63\times0\cdot15\times100}}$$

$$= 4\cdot95 \text{ amperes per square foot;}$$

hence
$$n = \frac{0\cdot15}{0\cdot15+\frac{0\cdot02}{4\cdot95}}\times63,$$

$$= 61 \text{ tanks,}$$

$$\gamma = \sqrt{\frac{(1-\frac{1}{36})\,24{,}000}{61\times0\cdot15\times100} - \frac{0\cdot02\times4\cdot95}{0\cdot15}}$$

$$= 4\ 97 \text{ amperes per square foot,}$$

and
$$C = \gamma S = 497 \text{ amperes,} \qquad V = \frac{24{,}000}{497} = 48 \text{ volts.}$$

The cost of depositing *one* lb. of copper will be

$$U_{(\text{min.})} = \frac{768}{10}\left\{\frac{(360+50)\,0\cdot15}{(1-\frac{1}{36})\,24{,}000}\cdot\frac{6\cdot5}{100}\right\}^{\frac{1}{2}}$$

$$= 1\cdot01\text{d.}$$

The curve marked (1) in Fig. 2 has been drawn to show what effect altering the number of tanks has on the cost of depositing (S remaining constant, and using the data of this example). It will

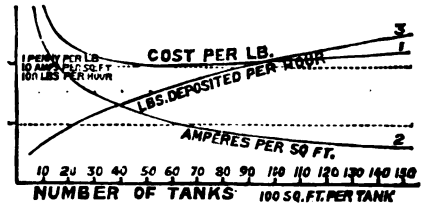
COST PER LB.
3
1
LBS. DEPOSITED PER HOUR
AMPERES PER SQ FT.
2
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150
NUMBER OF TANKS
100 SQ. FT. PER TANK

FIG. 2.

be observed that the cost is a minimum when n = 61, and that it increases when n is either increased or diminished. Of course, C V is supposed to be constant, and consequently γ will very, increasing as n diminishes and *vice versâ*. Curve (2) shows the manner in which γ varies. Curve (3) shows the number of pounds of copper deposited per hour for the corresponding values of n. From this curve it appears that the number of pounds of copper deposited per horse-power is no criterion of the merits of an installation.

Example No. 2.

Let CV = 24,000 watts, S = 100 sq. feet, ϕ (S) = 6·5 pence, A = 200 pence (water-power), B = 50 pence, r = 0·15 ohm, ϵ = 0·02 volt, $a = \frac{1}{16}$, working 10 hours a day;

then
$$n_1 = \frac{200+50}{6\cdot5} = 38$$

$$\gamma_1 = \sqrt{\frac{(1-\frac{1}{16})\,24{,}000}{38\times0\cdot15\times100}}$$

$$= 6\cdot23 \text{ amperes per square foot;}$$

$$n = \frac{0\cdot15}{0\cdot15+\frac{0\cdot02}{6\cdot23}}\times38 = 37;$$

$$\gamma = 6\cdot28 \text{ amperes per sq. foot;}$$

$$C = \gamma S = 628 \text{ amperes,}$$

$$V = \frac{24{,}000}{628} = 38 \text{ volts,}$$

$$U_{(\text{min.})} = \frac{768}{10}\left\{\frac{(200+50)\,0\cdot15}{(1-\frac{1}{16})\,24{,}000}\cdot\frac{6\cdot5}{100}\right\}^{\frac{1}{2}}$$

$$= 0\cdot8\text{d.}$$

Example No. 3.

Let CV = 4,000 watts, S = 100 sq. feet, ϕ (S) = 6·5 pence, A = 70 pence, B = 40 pence, r = 0·15 ohm, ϵ = 0 02 volt, $a = \frac{1}{25}$, working 10 hours a day;

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then

$$n_1 = \frac{70+40}{6\cdot5} = 17$$

$$\gamma_1 = \sqrt{\frac{(1-\frac{1}{25})\,4,000}{17\times0\cdot15\times100}}$$

$$= 3\cdot87 \text{ amperes per sq. foot,}$$

$$n = \frac{0\cdot15}{0\cdot15+\frac{0\cdot02}{3\cdot8}} = 16$$

and

$$\gamma = 3\cdot95 \text{ amperes per sq. foot,}$$

$$C = \gamma S = 390 \text{ amperes,}$$

$$V = \frac{4,000}{390} = 10\cdot1 \text{ volts,}$$

$$U_{(\text{min.})} = \frac{768}{10}\left\{\frac{(70+40)\ 0\cdot15}{(1-\frac{1}{25})\ 4,000}\cdot\frac{6\cdot5}{100}\right\}^{\frac{1}{2}}$$

$$= 1\cdot28\text{d.}$$

PROF. FORBES' CANTOR LECTURES.

LECTURE III.

(Continued from page 57.)

I will carry the analogy still further; but I will remind you of the remarks which I made in my lecture on what are called electric potentials. I said there was a difference of electric potential between any two bodies which were electrified, one positively and the other negatively, so also I say there is a difference of potential between the two ends of this magnet. I said that we meant by a difference of potential that work was done in carrying something from one point to another. There is a difference of potential between a floor and a table, because work is done in lifting a mass from the floor to the top of the table. There is also a difference in magnetic potentials between the two ends of a magnet, because work must be done in carrying a magnetic pole from the one to the other. The condition which determines a rearrangement of the magnetic state, owing to the existence of the magnetising force, is called magnetic induction, and the effect produced in any given case depends partly upon the direction in which the magnetic force is acting and partly upon the substance and shape of the body which is being acted upon. Iron offers less resistance than any other material to the induction due to the magnetising force. I have here a compass needle suspended, which will enable me to illustrate some of the phenomenon of induction by throwing the image on the screen. [Experiment.] The compass needle is now suspended in a certain direction. I wish to show the induction of magnetism in a piece of iron by subjecting it to a magnetising force. We know from what has already been said that the earth's magnetism acts in a north and south plane, and, moreover, that in these latitudes the vertical component is much greater than the horizontal. At present, therefore, the bar, being held in a nearly perpendicular position, is subject to the action of the magnetising force of the earth, which is trying to pull the north end downwards and trying to drive up the south magnetism at the other end. If this were a magnet freely suspended, as the dipping needle was, and if this were the north end, this bar would set itself in this direction [indicated]; but it has no magnetism of its own; its magnetic properties are entirely due to the inductive action of the earth. I will try and show you that this is the case. If that is the case, then the earth is creating a north pole at the lower end of the bar and a south pole at the upper end, and even if I reversed the iron bar we should still have a north pole at the lower and a south pole at the upper end. [Shown.] I will bring the upper end first towards the needle. You see the direction in which the needle tends to go—that is to say, it assumes a horizontal position, as shown on the screen. [Shown.] The opposite end of the iron will certainly be found to be magnetised in the opposite direction. Now, the remarkable thing I wish to show you is this—that when I twist the iron round, I shall reverse the polarity of the iron bar. I now present that end of the bar which deflected the needle vertically before, and it deflects it horizontally now [showing], and the other end deflects it in a vertical, instead of a horizontal, position.

I wish now to show you some effects which enable us to get a very fair notion of the ultimate nature of the magnet. I have mentioned that in the laboratory it is not very convenient customarily to use pieces of loadstone as magnets, but that we use magnets which have been artificially made. We can convert pieces of common steel into magnets in a variety of ways. One way is by making use of the loadstone itself and drawing one of the poles over the piece of steel. On drawing the losdstone over the piece of steel always in the same direction the steel is converted into a magnet. Here is a piece of steel tape. First, I will show you that it is not sensibly a magnet, that it does not seriously influence the compass needle. Now, I lay down this piece of steel tape and draw the poles of the magnet over it always in this direction. [Indicated.] By this means I am producing a magnetising force, and that is an action very much the same as was produced by the earth's magnetism on the soft iron. The only difference is that this steel is a material which, when it is magnetised, does not lose its magnetism easily. Therefore, it is not easily reversed, as you saw in the iron bar. I have now stroked this over several times with one of the poles of this magnet. On bringing it into the neighbourhood of the compass the needle is violently deflected [shown], thus showing that this steel tape has been converted into a magnet. One end attracts the needle into a horizontal position, and the other end reverses it. Now, the whole of this magnetism appears to reside in the two ends of the magnet, and it might be thought that upon breaking this steel you ought to have the whole of the north magnetism at one end, and the whole of the south magnetism at the other. I will try the experiment, and see what happens. [Shown.] I have broken the steel into two portions. I bring each end in turn towards the needle, and it is moved in opposite directions. It is the same with the other fragment. The two ends still have opposite polarities when I have broken the magnet in two, and I might go on breaking it again, and still there would be both north and south polarity in each of the fragments. I might, in fact, go on breaking it a great many times, but I should always have the two poles north and south. I will now demagnetise this piece of steel. This is done by heating it to a red heat in a Bunsen flame. The steel loses its magnetism when sufficiently heated. I will let it cool, and then bring it to the needle and test it, and nearly the whole of the magnetism will probably disappear. In the meantime I may say that from the fact that we cannot find the whole of the north magnetism at one end of the magnet and the whole of the south magnetism at the other, and that when we break it we always find both north and south magnetism in the same piece, it has been supposed by many that it does not matter how far you were to subdivide the iron; if you were to break it down to small pieces you would always have opposite magnetisms at the two ends of the iron—that is to say, carrying it to the extreme limit that the actual molecule of iron is magnetised and has magnetic polarity, one end of the molecule being north and the other end being south. This is a theory which is now pretty generally accepted. The steel tape is now cold; having brought it under the influence of heat, and allowed the molecules to vibrate about a little and arrange themselves in a new manner, they have no longer that linear arrangement which constitutes magnetism, so that we have destroyed the magnetism in this piece of steel, as you see when I bring it near the compass needle. [Shown.] The theory, as generally accepted nowadays, is that molecules are all magnetic intrinsically, and that in *every* piece of iron the molecules are of that nature, but that when we subject the iron to a magnetising force, then we arrange the direction of those molecules so as to be all parallel to one another, and in the same direction. It is perfectly clear that if we had a lot of little magnets all arranged in the same direction and parallel to each other—with all their north poles pointing in the same direction and their south poles pointing in the other direction—then the whole group of these magnets would act as one large magnet does. They would attract the compass needle in exactly the same way as we find a magnet attracting the compass needle. Moreover, we know that if a mass of iron were so constituted—made of molecules having intrinsic polarity—and that if it were subjected to a magnetising force, and if those molecules were free to move, they would arrange themselves in one direction; and thus the whole mass of iron would evince magnetic properties just as you saw the iron bar do when subjected to the inductive action of the earth's magnetism. This is the theory of magnetism which is most generally accepted. I have shown you one way of converting iron into a magnet. But we have another, and a much more potent manner of doing so, and that is by the aid of an electric current, and with the discovery of this power in an electric current to convert iron into a magnet the field was opened for an enormous number of practical appliances of electricity and magnetism. I will now show you electro-magnets of different shapes and the effects which can be drawn from them. The first one which is suspended here [indicated] simply consists of two flat discs of iron, with a groove between them. In the groove is a coil of iron wire. I shall pass an electric current through the wire, and now it has become a powerful magnet able to support a very heavy weight. When we look at the small size of the magnet and the considerable weight supported, it is most striking. This is the most powerful electro-magnet I have seen for its size. There is another electro-magnet of a different form. This is a horseshoe of iron, round which are coils of wire. At the present moment it has no influence whatever. It is not magnetised at all. Only as soon as contact is made completing the electric circuit you see it requires considerable force to lift off the armature. [Shown.] Now I will connect the two poles by means of this keeper, and then the force with which it attracts is something enormous. I can lift the magnet bodily up by this keeper. When I first had this magnet I was showing an experiment, and I told the audience that as soon as the current ceased to circulate in this way the magnetism would disappear. But to my astonishment on trying it I found it did not disappear at all. There is no current passing through the wire at present, but still the iron attracts the keeper. If, however, I force that iron keeper off, the magnetism absolutely disappears. As a matter of fact, this piece of iron is so remarkably soft that the magnetic induction continuously taking place through the iron must retain this arrangement actually after the magnetising force has been removed. I will give an experiment which suffices to show that when the current disappears the magnetism disappears—that is, if you let the keeper only just touch the two poles of the magnet. As soon as the current stops the magnetism stops too. But when I have the iron formed in a complete ring, so that all the molecules are end to end, it retains its strength after the current has ceased. There is another interesting experiment in which instead of the solid keeper I use a mass of horseshoe nails, which form a bridge from one pole of the magnet to the other, and which present a curious appearance of rigidity; but directly the current is broken off they all part. Faraday, when he was engaged in his brilliant researches in magnetism was accustomed to study the nature of induction and the direction of magnetic induction in space by means of iron filings. I have here a small horseshoe magnet, and I shall project its image on the screen. Then I shall dust the magnet over with iron filings, and you will see the direction in which they lie. Each little piece of iron

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filing is converted temporarily by the force of this magnet into a magnet itself, and it settles itself in the direction which the inducing force of the magnet tends to give to it. [Shown.] You notice these beautiful curves crossing the poles, which come out more clearly when I tap the glass gently, thus, so as to allow the filings to arrange themselves. In the first place, you see there is always a tendency for the curves to go from the north pole to the south pole. At every point the direction of the filings indicates the direction in which induction is taking place at that particular point. I am not going very far into the question of these lines to-day, but Faraday thought a great deal about these lines of force, and the arrangement he used is of very material aid to understand some of the more difficult problems of electricity which we shall be coming to in the succeeding lectures. If we suppose that a magnet does consist of little pieces of iron with north and south polarity going all the way round, then these iron filings continue the chain, and we have a continuous line of force going right through the magnet and from one pole to the other through space. Others only go part of the way through the iron; they emerge at the sides and come back across the intervening space, re-entering the iron at a point symmetrical with that at which they emerged. But by a study of the direction of these lines of force we are able to get a great insight not only into the theory of magnetism, but into the magneto-electric phenomena which we shall be having presently. I will now throw on the screen another illustration of the same kind, in which I have unlike poles passing each other, and you will see the direction which the lines of force will take when we strew the iron filings there. [Shown.] The general tendency is to cause the lines of force to cross from the north pole to the south pole, not only in a direction straight across, but also in every direction in space. They may take all sorts of different directions, but they are always passing from one pole to the other; the lines, however, never cross one another. The lines of force thus go right through the iron, and it is very important in the conception of lines of force to retain that notion that these lines are continued through the iron, and that this arrangement of molecules, of which I have spoken, is really existing in the iron. This is a very beautiful means of studying the phenomena of induction, and the condition of the magnetic field in the neighbourhood of the magnet. I have been speaking about these ultimate small particles of iron as being magnetic in themselves, and I should mention here a further theory, or hypothesis, which has been advanced to account for the existence of magnetism in these ultimate molecules. This is a theory which the great French philosopher, Ampère, proposed. He suggested that a molecule of iron is nothing more nor less than a circular current of electricity. If a current of electricity could be created in a circular piece of metal, and if that metal offered no resistance to the current passing, that current of electricity would go on for ever, and what Ampère suggested really amounted to this, that a molecule of iron is a perfect conductor of electricity in which an electric current had been established when it was created, and, consequently, the electric currents are going on continually circulating in those molecules. I can show you this much that if we had a circular current of electricity the action would be such as Ampère described. Here I have a coil of wire, the two ends of which are attached, one to a piece of copper and the other to a piece of zinc. I shall dip this coil into a vessel which is floating in a glass dish. Now this coil of wire has a current of electricity in it because the metal is dipping into a solution of acid and water, and we find that the coil takes up a position so that its axis is in the direction of the magnetic meridian. So long as there is a current of electricity passing through it I can show you that the action of the magnet upon it is similar to the action of the magnet upon another freely suspended magnet. I can do that by means of this bar magnet I employ, and according to the side of the coil on which I approach that pole. [Experiment.] You see now it turns round and presents the other face towards me. I can attract the whole thing bodily towards the side of the vessel. The other pole will attract the other side of the coil. Thus, whatever magnetic force I have in the end of this suspended coil it will always tend to set itself with its axis parallel to the magnetising force in the same manner as a freely suspended compass needle would do. Finally, I may force the coil to pause over the bar of iron, and to run along the whole length of it, showing the different series of actions which are exercised between the magnetic bar and the circular coil, which has a current of electricity passing through it. This is the typical magnetic molecule, which Ampère suggested as being the true molecule of iron, and if we can conceive of a molecule having a current of electricity revolving round it like that, the whole of the actions of magnetism would take place just as we know them to be. This is what I meant when I said that probably we should find that magnetism is also another development of electricity to that which we were examining in our last lecture.

It was shown first by Joule that when we magnetise an iron bar its length is increased. It has been supposed by some that this is due to the fact that those magnetic molecules of iron are of elongated form, so that when a magnetising force acts on them so as to put their lengths all in the same direction they naturally take up more space lengthwise than if they were all higgledy-piggledy in different directions. Whether that is the true explanation or not I should not like to say. The experiment that Joule showed proved conclusively that iron does expand when it is magnetised. This is a very important experiment, which I believe is destined to give us a great deal of information in the future as to the nature of magnetism. This is an experiment about which we know very little as yet, but a great deal has been done in the course of the last year or two, and the astonishing fact has been discovered by Mr. Bidwell that not only does iron expand when we put it into a magnetic field of a certain strength, but that if we increase the strength of that field and the power of the induction acting on the iron to a considerable extent, we diminish the action on the iron—that is to say, that as we increase the magnetising force, we first get expansion, and afterwards as the force is still further increased we get an absolute contraction, and the contraction is very much greater than the expansion which had been investigated by Joule. I am fortunately able to show you this experiment, which Mr. Bidwell has been kind enough to set up for us, and if he will kindly give me his assistance we will throw upon the screen an image of it by the lime light. I will indicate a part of the arrangement. Here is a piece of iron bar that is fixed at the lower end. At the upper end there is a mirror moving on a pivot, and a lever attachment so connected with the bar that if the piece of iron lengthens it will give motion to the mirror, and a spot of light reflected from it will be seen to change its position. If the iron were to grow shorter the spot of light would be seen to rise up the scale. I will first commence with a comparatively feeble magnetising force. The black line on the scale is a fixed wire reflected by the mirror, and when I pass a current round the iron wire so as to magnetise it with a comparatively feeble current we shall probably see a descent of that line, indicating that the iron has expanded in length. [Experiment.] There is a motion of about an inch and a half or so. I will now ask Mr. Bidwell to put on a stronger current, and you notice the very large contraction indicated by the rising spot of light. This shows the contraction of the iron when we use a sufficiently high magnetising power. This was not noticed by Joule, because he did not use a strong enough current. I will show you that nickel, one of the other magnetic metals, always contracts. I might mention that the total movement is something extremely small, something like a millionth of the total length, and as the piece of wire is only 3in. or 4in. long, the enlargement which we are obliged to have to make it visible is very great; but this mechanical arrangement of Mr. Bidwell is very satisfactory indeed. On introducing the nickel we find a rise of several inches when contact is made. The feebler power that gave expansion with iron gives a small contraction, but on increasing the power we have an enormous rise—that is, an enormous contraction, far greater than the effect we got with iron.

(*To be continued.*)

ELECTRICITY AS A SAFEGUARD AGAINST FIRE.*

The application of electricity to the prevention of fire may conveniently be classed under the following heads:—(1) The application of electricity to summon assistance. (2) The communication from a police or fire station when an alarm is given to the head and branch stations of the fire brigade. (3) Communication from alarm boxes worked automatically to police or fire stations. (4) Automatic apparatus giving an alarm on pyrometrical principles.

Under the first heading we have the system shown here by Captain Davis, the efficiency of which any of you can easily test by taking a pull at his fire bell. This system, now generally adopted all over the world, has been most elaborated in the United States and Canada. There, on an alarm being given, the current causes the doors of the fire station to open; the horses, trained to it, leave the stable and place themselves before the engine; the harness, which is suspended over it, drops on them, and in seven seconds the engine dashes out. Thus in less than a minute after the alarm has been given the first engine might be on the spot. In San Francisco, the brigade, to save a few critical moments, have a boiler in the basement which is connected, by means of an inlet and outlet pipe, with the boiler of the fire engine, the water being always kept at boiling point; the connection between the boilers being broken off electrically by the current giving the alarm.

The second system has been adopted in most large towns in this country, on the Continent and in America. One great advantage of a telegraphic system over a verbal alarm being the possibility of recording particulars of the first indication and subsequent orders given over the wires, which in many large towns are connected with all the telegraph offices, police offices, and the water offices. Fire messages ought undoubtedly to have precedence over all ordinary messages; but except in the case of messages handed in by police officers, I doubt the wisdom of carrying messages free of charge, as has been suggested. Under the third heading we have a system which has secured an earlier and more rapid adoption on the Continent and in America than in this country, and one of the most complete applications of it is the Automatic Fire Telegraph System, the primary object of which is to reduce to a minimum the time intervening between the discovery of a fire and the presence of a brigade on the spot, it being generally conceded that the chances of a fire becoming serious increase at least as the square of the time between the outbreak and the arrival of the brigade, delay meaning rapid increase of heat, the elimination of moisture from surrounding materials, thus rendering them more inflammable and causing the fire rapidly to assume serious proportions. The principle on which the fire telegraph system at present in use is based is the establishing in sufficient numbers, and in easy accessible places, of suitable apparatus by which information of the outbreak of a fire may be communicated by any person to the nearest fire engine or police station, or to a central station from whence immediate orders are issued, and by it a sign may be telegraphed to the central station indicating the street and district where the alarm of fire is given. The apparatus is a simple mechanical contrivance introduced into the telegraph line, through which circulates a permanent current of electricity from the battery in the central station. When brought into action the annunciator breaks the circuit and signals the central station. The breaking of the circuit is caused by the rotation of a contact wheel, the periphery of

* Paper read at the Balloon Society by Mr. Alfred Thompson.

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which is so shaped that the contact breaking corresponds to a given Morse signal, and each signal to a given district and street of a town. As many of you have seen, the annunciator is protected by a glass front, and placed at street corners, in railway stations and other suitable sites, and printed directions are affixed to it that in case of fire the glass is to be broken and the handle pulled. When this is done the contact wheel rotates and the letter corresponding to the annunciator is transmitted several times in succession to the central fire station, whence orders are telegraphed to the various engine and police stations. In some cases dial instruments have been adopted in connection with these telegraphs ; but a Morse self-starting recorder has, I believe, been found more reliable. The automatic annunciators have, besides the contact wheel, a Morse key, a galvanoscope, and a lightning protector. By means of the key messages can be sent to the stations of the division if required.

It would appear that there is now a general consensus of opinion—1. That towns without fire telegraphs are liable to very high percentage of serious fires, the cause being unquestionably the time lost in calling out the fire brigade. 2. That the employment of fire telegraphs in all cases leads to a decrease of the percentage of serious fires ; and that the more perfect the fire telegraph is, the greater the reduction in the percentage of serious fires.

Another system, termed the "Auto-Kinetic Automatic," claims that it enables uninterrupted messages to be sent at will, as the instrument waits until the first message is delivered before delivering a second, which is analogous to the block system on railways, and obviates the employment of an open circuit, thus saving battery power and the deterioration of underground wires. For some time after the adoption of the Bright telegraph fire system in England certain disadvantages were found in working it ; but these were easily attributable to the fact that the lines were worked by three services, viz., the fire brigade, the police, and the post office, and that the lines were chiefly overhead, and were in some cases intermingled with post office underground wires. To obviate the great difficulty experienced in finding faults in underground wires, an invention of Sir Charles and Mr. E. B. Bright was patented, in 1852, for ascertaining the locality of faults in telegraph conductors by means of a set of varying resistance coils brought successively into a local balancing circuit in connection with a differential galvanometer, the other side of which was joined to a faulty wire, this being continued until the balance of the needle was arrived at, and the distance to the point of fault thus known. Messrs. Brights' system of fire telegraphs has been adopted to some extent in this country.

Mr. Spagnoletti, Ex-President of the Society of Telegraph-Engineers, directed his attention to electric fire alarms. His system is as follows :—At selected points a post is erected, in the top of which is the apparatus. To give an alarm of fire you have to pull a handle ; to get at the handle a pane of glass has to be broken ; when the handle is pulled a bell rings at the post to satisfy the sender of the signal that he has sent it. At the engine house is an instrument with a dial, round which is painted in clear letters the name of each place at which a post is erected ; a pointer travels round the dial (like the minute hand of a clock, only quickly) and stops pointing at the name of the street from which the signal has been sent, on receipt of a signal, which is instantly seen, and attention is also called to it by the ringing of the bell, the engine is despatched, and then the man acknowledges the signal to the "post," sending it by simply pressing in a "plunger" ; this stops his bell ringing and puts the pointer of the instrument to zero ; at the same time it resets the apparatus at the post, and the apparatus at the post acknowledges itself reset by the deflection of a "needle" at the engine house, and is a guarantee to the engine-house man that the whole system is again restored to its proper condition for another signal. By keeping this needle in deflection to the wire, all the posts and apparatus is kept under a constant test showing all is in good and working order ; if anything fails the needle falls perpendicular, and a bell starts ringing to give notice of the faults. I have another system by which the name of the street from which the alarm is sent is dropped in a hole and shown, and a bell is rung at the same time to call attention to the signal. For large buildings, asylums, &c., the system is different. A wire is run round the building, and a loud bell is placed wherever required on the wire ; any number of bells may be put on the one wire ; at certain points as many as desired contact makers are placed from which alarms are sent, and anyone sending a signal from any of these points starts all the bells off, which continue ringing until stopped. A place of meeting, generally the engine house, is arranged, and as soon as the fire bells are heard the brigade all run to the engine house, as does also the person sending the alarm, and he then gives the locality of the fire.

To illustrate the advantage of self acting fire alarms, a case is on record which occurred in New York, where a building was protected by them and had its wires in direct connection with the nearest fire station. A fire started and the thermostats gave the signal. Before it was known to anyone in the building the engine was at the door. The watchman in the building, declaring roundly there was no fire, refused admission. An entrance was forced and a fire quickly extinguished on the fourth floor, where it had started.

I would now like to quote a few statistics, showing results obtained through one application of electricity under heading 4, viz , thermostats or fire detectors. The benefit of a thermostat, or fire detector system, has been most fully recognised in the United States, where in several of the larger cities very large and complete installations have been made of them ; and from returns made a few years ago by the New York Fire Patrol Committee, it was shown that, apart from the number of lives saved, the result of nearly three years' working of these self-acting alarms had been the reduction of three-fourths of the loss to property in the case of fires which started on premises protected by them. The insurance losses paid on fires in buildings so protected, and which were detected and automatically noted by the apparatus, amounted to $396,909. The amount insured on these buildings and their contents amounted to $7,031,000, the proportion of loss to insurance in these cases being only about 5½ per cent. On the other hand, the insurance losses on risks in the same class of buildings not so fitted was no less than $4,530,928, as against an insurance of $18,990,901, or a loss to insurance of nearly 24 per cent. And it is well to remember in this relation that the means for extinguishing were the same in both cases, the difference of about 75 per cent. in favour of the electrically protected premises being solely due to the rapidity to which the alarm was given by the automatically acting thermostats. In English money the saving in the case of the buildings first referred to was £258,000, and had the unprotected buildings, in which fires occurred, been protected, the saving to the insurance offices would have amounted to £692,000. The insurance companies ultimately woke up to the force of the above facts, and, after the American companies had offered large abatements in premiums on buildings fitted with thermostats, the English companies insuring property in America speedily followed suit.

I now turn for a moment to the introduction of automatic mechanical fire extinguishers, of which we have those of Grinnell and Parmillee, in America ; Victor Van Keer Bergen, in Belgium ; Alfred James Eastwood and Messrs. Dowson and Taylor in this country. The purpose aimed at by these gentlemen was similar to that which is obtained by the system patented by myself and Mr. Ritchie in the early part of this year. And, regarded as mechanical contrivances, their inventions are deserving of every praise. Statistics collated by Mr. Woodbury from the books of the Factory Mutual Insurance Companies of New England show that during a period of eight years from January, 1877, to January, 1885, the number of fires occurring in buildings not protected by sprinklers was 553 ; that the number of fires protected by sprinklers was 195, giving a total of 748 ; that the average loss in the 553 fires (unprotected) was £1,624, as against an average in the case of the 195 protected buildings of only £70—a difference in favour of the latter of £1,554. The advantage of using fire sprinklers will thus be perfectly obvious. Under the heading No. 4, I class the automatic "electric" fire extinguisher, a model of which you may observe on the table before you ; and I ought to mention that in patenting this invention the consideration that has had most weight with us is the very remarkable results which have, as I have endeavoured to show you, followed when merely mechanical contrivances have been superseded by those electrical. We have seen how electric fire alarms have gradually relegated to the back ground pre existing methods of working ; and if the results, as ascertained from careful statistics, show the vast superiority of all electric fire alarms, it is with stronger reason to be anticipated that the apparatus which you see before you, and which not only gives a fire alarm at any desired point, but shows on an annunciator the the exact site of the fire, and at once sets to work to grapple with the fire independently of all outside means and pending their arrival, has an important future before it.

The advantages of the automatic electric fire extinguisher are :—1. Its instantaneous action on the occurrence of a fire, either during day or night. 2. Its perfect automatic action and independence of human aid, more especially where fumes of smoke might endanger human life. 3. The confinement of a fire to the point where it originated. 4. The discharge of water is confined to the site of the fire, or, if desired, can be extended to an area immediately surrounding it by bringing into action extinguishers in its immediate vicinity. 5. It admits of frequent testing to prove it is in working order, without expense or inconvenience of any kind. 6. It admits of automatically turning the water into the pipes after it has, through the action of the thermostat, been run out automatically on a fall in temperature to near freezing point.

Before concluding I would like to say a word or two on two other branches of electricity which bear upon this question, viz., telephones and electric light. I am not aware that telephones have ever been practically used in connection with fire telegraph systems ; but no one can doubt the great use that may be made of them in summoning assistance to a fire. I also claim for electric light that it is essentially a preventer of fire. It imparts very little heat as compared with other illuminants, and cannot in the case of incandescent lighting be brought into contact with inflammable material. To illustrate this an incandescent lamp fully incandesced may be carried about amongst inflammable gases without igniting them, or be suddenly broken when enveloped in muslin without setting fire to it.

PHYSICAL SOCIETY.—May 8th.

Prof. H. McLEOD, F.R.S., Vice-President, in the chair.

Mr. W. A. Price was elected a member of the Society. The following communications were read. "On a Modified Form of Wheatstone's Rheostat," by Mr. SHELFORD BIDWELL. A wire is coiled upon a non-conducting cylinder as in the ordinary forms of rheostat, one end of the wire being in contact with the brass axle of the cylinder. A screw is cut upon the axle, the pitch being equal to the distance between the consecutive turns of the wire, and this, working in a fixed nut, causes the whole cylinder to travel in the direction of its axis. A fixed spring bears upon the wire at a convenient point, and by the travelling motion of the cylinder this point of contact remains fixed in space, and the effect of turning the cylinder is to introduce more or less resistance between the spring and the brass axle. Binding screws on the base of the instrument are in contact with the nut and the bearing spring. Though this arrangement has several obvious advantages over the usual forms, Mr. Bidwell does not recommend it in cases where it is required to introduce a known resistance ; but where it is important to adjust a resistance to a nicety, or to cause a continuous variation, it is of great use. Prof. PERRY, remarking upon the importance of being able to vary a resistance gradually, described an instrument he had used with advantage. A number of plates of gas

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carbon are placed between two parallel copper plates, one of which is fixed, and the other adjustable by a screw; by applying pressure by means of the screw the resistance between the plates can be varied uniformly and regularly from 2 to 10 ohms, beyond which point the increase is very rapid.

On a "Theorem Relating to Curved Diffraction Gratings," by Mr. WALTER BAILY. In a paper read before the Society in Jan. 1883, the author showed that if a plane be taken perpendicular to the lines of a curved diffraction grating, and a normal to the grating be taken as the initial line, then the equation

$$\frac{\cos^2\theta}{r} = \frac{\cos\theta}{c} + \frac{1}{d}$$

in which c is the radius of curvature of the grating, and d is an arbitrary constant, gives a curve having the property that if a point of light be placed anywhere upon it, the curve is the locus of the foci of all diffracted rays, whether reflected or transmitted. In the present investigation d is supposed to be greater than c, which allows of the source at light being at infinity. The points where the curve given by the above equation cuts the normal are called the normal foci. There are two of these, one relating to the reflected and the other to the transmitted light, the grating being supposed to consist of a number of opague lines in space. It is then shown that if the grating be supposed to turn about the line in it intersecting the initial line, the normal foci will trace out two parabolas whose common focus is the origin, and common latus rectum is equal to the diameter of curvature of the grating, the parabola for reflected light being convex to the source of light, and that for transmitted light, concave.

"On Some Thermodynamical Relations," Part IV., by Prof. W. RAMSAY and Dr. SYDNEY YOUNG. The first part of this communication deals with Profs. Ayrton and Perry's criticisms upon the previous papers by the authors upon this subject. In the second part a brief review is given of the various attempts that have been made to represent the pressure of a saturated vapour as a function of the temperature.

MAY 22, 1886.—Prof. BALFOUR STEWART, President, in the Chair.

Messrs. C. A. Bell, W. C. Johnson, and James Swinburne were elected members of the Society.

The following communications were read:—"On the Sympathetic Vibrations of Jets," by Mr. CHICHESTER A. BELL. It has been assumed hitherto that a gaseous or liquid jet vibrates under the influence of a limited range of tones only, effective tones being those which do not differ greatly in pitch from the normal or proper tone of the jet, discovered by Savart and Sondhauss. The author has found, however, that when the pressure under which a jet escapes is not too great, the latter is affected by all tones lower than the normal, as well as by some above it. Changes may be excited in a jet of either kind, by vibratory motions of the jet orifice, or of the fluid behind, or external to the orifice. These changes take the form of slight swellings and contractions, which become more pronounced as the fluid travels away from the orifice, and finally cause the jet to break or become discontinuous at a distance which depends upon the intensity of the initial disturbances. At any point within the continuous portion of the jet the successive swellings and expansions represent both the form and the relative intensities of vibrations impressed upon the orifice; and the jet is, therefore, capable of reproducing very complex sounds, such as those of speech and music. A vibrating jet of air does not, however, emit sound when it plays with free air, or into the wide end of a tube communicating with the ear; but when it plays against a very *small* orifice in the end of a hearing tube loud sounds may result. This reproduction is most intense when the hearing orifice is placed in the axis of the jet, just within the breaking point; but becomes gradually feebler as the hearing orifice is moved towards the jet orifice, or out of the line of its axis. Beyond the breaking point the sounds from the jet at first become confused, and finally are lost. A jet of gas, like a liquid jet, only vibrates so as to produce its normal tone when it strikes upon some obstacle which serves to diffuse the disturbances due to impact or throw them back upon the orifice. The vibrations of an air jet are also loudly reproduced as sound when it is directed against a small flame below the apex of the blue zone. Liquid jets are but slightly sensitive to aerial sound-impulses, but become highly sensitive when the jet tube is rigidly attached to a sound board. The vibrations of a jet so mounted are best perceived as sound when the stream strikes upon a rubber membrane tied over the end of a narrow tube which communicates with the ear. For accurate reproduction of speech and sounds in general the jet should be at such a pressure as to respond visibly to a note of about 4,000 vibrations per second, and the membrane should be at such a distance from the orifice that the jet never breaks or becomes discontinuous above its surface. The vibrations of very fine jets of any conducting liquid become loudly audible when a portion of the jet or the "nappe" formed when it strikes upon a flat surface is included in circuit with a battery and a telephone. This may be accomplished by letting the jet impinge on the end of an ebonite rod, through the centre of which passes a platinum wire; the upper end of the rod is surrounded by a short tube or ring of platinum, the upper margin of which forms a continuous slightly convex surface with the exposed end of the central wire and the ebonite. The wire and ring form the terminals of the circuit which is completed through the nappe. Distilled water containing $\frac{1}{300}$th of its volume of pure sulphuric acid is recommended as the jet liquid. The author advances a new theory to account for the growth of the vibratory changes in liquid and gaseous jets.

"On Some Thermodynamical Relations," Part V., by Prof. W. RAMSAY and Dr. S. YOUNG. In Parts I. and II. of this series of papers it was shown that the ratio of the absolute temperatures of any two bodies corresponding to a given vapour pressure bears a simple relation to the ratio at any other pressure, which may be expressed by the equation $R' = R + c(t' - t)$, where R' and R are the two ratios, c is a constant, and t' and t are the temperatures of one of the two bodies. The determination by Schumann (*Pogg. Ann.* N.F. 12, 46) of the vapours of methyl formate and 27 homologous ethers made it possible to compare the vapour pressures of a large number of bodies belonging to the same class. It was found that when the ethers were compared with ethyl acetate, which was taken as the standard, in every case $c = 0$, and therefore $R' = R$. The temperatures corresponding to the three pressures 200, 760, and 1,300mm. are given by Schumann. Taking the mean value of R for those pressures as correct, and recalculating the temperatures, the greatest difference between the found and recalculated temperatures is 0·7°C. The vapour pressures of water or any one of the ethers being accurately known, it is sufficient to determine the boiling point of any ether belonging to this class, in order to construct its vapour pressure curve. The absolute temperatures corresponding to the pressures 200 and 1,300mm. for any ether are $\cdot 89795t$ and $1\cdot 0488t$, where t is the boiling point at normal pressure in absolute temperature.

A gridiron slide rule, by Mr. Stanley, designed by Mr. Thacker, was explained by Mr. C. H Boys. It was equivalent to a slide 60ft. long, and performed multiplication and division with an error not exceeding the 1-40,000th part.

Specimens of safety explosives, and their results in shattering blocks of lead, were exhibited by H. SPRENGEL.

COMPANIES' MEETINGS & REPORTS.

London Platino-Brazilian Telegraph Company (Limited).

The eighth ordinary general meeting of shareholders of this Company was held at the offices of the Company, Winchester House, 50, Old Broad-street, on Monday, 31st May, under the presidency of Mr. John Pender.

The SECRETARY (Mr. Wm. Payton) read the notice convening the meeting and the minutes of the previous meeting, which were confirmed and signed as correct. The report of the Directors and statement of accounts were taken as read.

The CHAIRMAN: Gentlemen—Before asking you to approve of the first resolution for the adoption of the report and accounts I have to make a few remarks. In the first place, I think it is right to mention that there are several difficulties surrounding us at the present time. Firstly, the telegraphs are suffering from depression of trade, which may be said to exist all over the world, and at the present time it is felt to a very severe extent in the Republic of Uruguay. Another difficulty is to obtain payment from the Government of that country. We are on perfectly good terms with the Government, and they are doing everything they possibly can to meet our requirements. Previous to this meeting we sent a telegram to our agent at Monte Video, in which we drew attention to the fact that our meeting was about to be held, and it would be necessary that I should have some facts and figures to put before the shareholders as to the debt owing to to us by the Government, and we received the following reply:—Extract from Señor Lanza, our manager's letter dated 29th April, 1886: "On the 21st I replied, saying that the Finance Minister was absent, and would not return until the following Monday, adding that I would communicate the result of my interview. The very same day that I communicated the foregoing to London I spoke to the President, to whom I translated Mr. Pender's telegram, and, after reminding him of the important services rendered lately by these lines, nevertheless without obtaining due attention to our claims, he answered more or less as follows: 'Already the Captain-General of the forces by land and sea has manifested to me that the line under your management has rendered the most important services towards the pacification of the country, working day and night with the most exceptional regularity and decided good will, and precisely for these reasons it is doubly painful for me to find myself unable to recompense such services by paying their full import. Soon, I expect, the Chambers will provide the means necessary for the payment of all back accounts, and then your Company will be immediately attended to. With respect to accounts appertaining to my administration, you should see the Finance Minister, to whom I will recommend immediate attention to you.' It was not until yesterday that I succeeded to speak with the Finance Minister, to whom also I translated Mr. Pender's telegrams, &c. He was more explicit in his reply, telling me 'that he could not guarantee the regular payment of accounts, posterior to the month of March, for the reason that the claims to attend to are very numerous, and the resources very few; but, nevertheless, in attention to the important services rendered by our line, he would do everything possible to favour me," and to-day they paid me $1,500 on account, which I communicated to the Chairman in the following telegram:—'Interviewed Finance Minister. Chambers discussing project to pay back accounts with bonds bearing high interest and amortization. Collected to-day $1,500. Money scarce; difficult job collecting.'" Then there is a telegram received from the same quarter, dated 14th May, which says:—"Law sanctioned creating new bonds bearing 8 per cent. interest and 4 per cent. amortization. Government service for February, March, and April reached $28,000. With $12,000 previously owing, makes a total of $40,000. This amount almost entirely will be paid with new stock at par. By first mail remitting £500." That shows you, gentlemen, pretty clearly the position of the Government. They are very desirous to pay what they owe us, and I believe they will continue to do their best towards this end. The second element of difficulty was referred to in our report for 1884 as follows:—"A difference has arisen between the Directors of this Company and the Western and Brazilian Company with respect to this Company's

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proportion of the receipts for telegrams sent since the reduction of tariff. Pending adjustment there has been brought into the accounts only the amount credited to this Company by the Western and Brazilian Company." The amount in dispute has been kept in suspense in the accounts; and it may yet have to be settled in a court of law. The third difficulty has been the loss of traffic on account of the competition of the Brazilian Government land-lines with the cables, which point is referred to in the report now before the shareholders:—"The competition for South American traffic with the cables of the North Atlantic and of the West Coast of America Companies has continued during the past year, and has seriously diminished the revenue of the Western and Brazilian Company, in which this Company is so largely interested." Our receipts from the Western and Brazilian Company in the past year amount to £8,614; in the previous year they were £10,655, and in 1883 they were £12,638, so we have not far to seek for the cause of the diminution in our dividend. As regards the future, there are negotiations pending. It is understood that the Chambers of Brazil have adopted a principle on which they will be prepared to make an offer to the companies interested in Brazilian telegraphs. The Western and Brazilian Company is the first company to be treated with, because they have the larger interest, but no arrangement can be come to without the concurrence of this Company. Now, gentlemen, I have shown you exactly the position that we are in now. We are suffering from depression of trade, we are suffering from extreme competition, and we have been suffering to some extent from the non-payment of our accounts. As to the first, I have given you full information; as to the competition, I suppose that will, as all competitions do, wear itself out, probably in a shorter time than we imagine, more particularly if the negotiations pending between the Western Brazilian Company and the Brazilian Government come to a successful issue. But whatever the result may be, we shall be able more or less to control those negotiations. I believe we have a right to do so, and in controlling them we should, of course, look after the interests of the Platino-Brazilian Company. With these remarks I beg to move the following resolution:—"That the report and accounts for the year ended March 31st, 1886, submitted to this meeting be, and they are hereby received and adopted; and that a dividend of 1s. per share be declared payable this day, free of income-tax; making with the interim dividend already paid, a distribution at the rate of 1 per cent. per annum." I might mention that since we assumed the direction of this Company we have paid altogether £52,600 in dividends, or an average of 2 per cent. per annum. We were urged to take up the work, and although we have not been able to pay you a large dividend, we have been able to give you at least something out of what appeared at the time we took office to be a total wreck.

Mr. JOHN HOLLOCOMBE seconded the resolution, which was carried unanimously.

On the motion of Mr. HOLLOCOMBE, seconded by Mr. PAVY, Mr. John Pender was unanimously re-elected a Director of the Company.

The CHAIRMAN: I am very much obliged to you for this renewed mark of your confidence. I wish I could say that there is a very brilliant future before us. All that I can say is that in any arrangements that have to be made we shall take very good care that the interests of the shareholders of the Platino-Brazilian Company are fairly protected. At all events we shall not take any definite steps towards a settlement without first calling the shareholders together.

Mr. WM. FORD then proposed, and Mr. J. W. FULLER seconded, "That Messrs. Deloitte, Dever, Griffiths and Co. be, and they are hereby re-elected auditors of the Company at a remuneration of £25 for the year."

The motion having been agreed to, a vote of thanks was accorded to Mr. Pender for presiding, and the proceedings terminated.

The West Coast of America Telegraph Company (Limited).

The ninth ordinary general meeting of this Company was held on the 2nd inst., at 50, Old Broad-street, under the presidency of Mr. Alfred Marshall.

The SECRETARY (Mr. F. L. Robinson) read the notice convening the meeting and the minutes of the last meeting. The report of the Directors was taken as read.

The CHAIRMAN said: Gentlemen, I have very few remarks to add to the report which you have received, and which shows the accounts of the previous year. You will remark that there is very slight difference in the working expenses, and the difference there is in the West Coast expenses is a saving in the course of the year. We hope that we may be able to maintain our expenditure at a similar low rate for the future. The "Retriever's" expenses are about £300 higher than in the previous year. This is a slightly varying item; sometimes the vessel may be docked at the end of the year, and sometimes at the beginning of the following year. This will account for such a difference as that which I have mentioned. I now come to the item of maintenance of cables. We have been very fortunate in not being called upon to make any extensive repairs, and on that item alone we have made a saving of £1,600. This we have thought prudent to take into consideration in recommending the addition of a comparatively large sum to the reserve, and we have no doubt that this will meet with the approval of all our shareholders. The gross earnings of the Company show, unfortunately, a falling off compared with the previous year. That is entirely, or almost entirely, attributable to bad trade. A great part of that was produced by the war that has been going on between Chili and Peru, and which has, of course, impoverished the people of that country very much. We can only look to an improvement in this direction gradually. There is one item which calls for explanation. It is in the interest account. You will see there is an amount of £381 placed to the credit, whereas it would naturally appear that the investment of £10,000 in our reserve at 8 per cent. would produce a larger sum. At the instruction of our auditors we have debited this account with loss on interest incurred by cable transfers. We have up to now adopted the plan of remitting money by cable transfer instead of by bills. This costs us a difference in the exchange, as bankers charge a higher rate of exchange, and at the same time we lose the difference of time between the purchase of the bill and the time when it arrives in England, and the three months which the bill has to run. We are taking measures to avoid this loss in future by resuming remittances by bills from the present moment. In fact, we are instructing our manager to-day to make this alteration immediately. I may inform you that the reports of our manager are very satisfactory in regard to the electrical condition and thorough working order of our lines, and we are doing everything in our power to keep them in satisfactory order. Our staff are, I believe, quite exceptionally efficient. We get information about all the errors that are committed in regard to messages sent to Valparaiso and coming therefrom, and every complaint that is made is investigated. It will be very satisfactory to you to hear that the last report we have received shows that of the few errors that were made not one for the last month for which we have received the report was committed by our staff. We keep a very close watch on the working of our men, and we hope we may continue to secure such good working in the future. With these remarks I propose the reception and adoption of the report. If any gentlemen present wishes to make any inquiries about any matter connected with the Company we shall be very happy to give any information in our power.

Mr. TAYLOR said that there was a saving, apparently, in the accounts of some £1,500, being a reduction in the West Coast expenses; but if they had not debited the expense of the remittances to interest account the West Coast expenses would have been some £400 or £500 more. The shareholders must therefore not consider that the West Coast expenses had been reduced by £1,500, but by about £1,000.

The CHAIRMAN stated that that was so. It was merely a matter of figures.

Mr. TAYLOR: Yes, but you take credit for £1,500 saved, and there is really only a saving of about £1,000.

The CHAIRMAN replied that the same principle was adopted last year, so that the saving really was as large as was shown.

Mr. TAYLOR admitted that in that case the saving was £1,500.

The CHAIRMAN added that he had referred to the matter because one or two questions had been asked him, and he had thought it would be better to answer them at the meeting.

Mr. LAMONT inquired whether the receipts this year were showing any improvement?

The CHAIRMAN said he was sorry to state that they were not showing an improvement. The total traffic up to May 31 had been £16,700 against £20,800 last year.

Mr. LAMONT: That is going the wrong way altogether.

The CHAIRMAN: In the last month there seems to have been a little sign of reaction, but very slight, and we hope that that will continue.

Mr. LAMONT: Peru has got a settled Government now.

The CHAIRMAN: Yes, settled in the same sense as before. Chili has got a settled Government, and has not had a revolution since 1859, which is saying a great deal for countries of that kind.

Mr. LAMONT thought that the prospects of the Company were not very brilliant at the present moment.

The CHAIRMAN: No; but we must hope for the best. We keep our lines in the best order ready to expand at any moment.

Mr. TAYLOR urged the Directors to do all they could to keep the expenses of the steamer down. The insurance was £1,164. That bore on the value of the steamer in the capital account, and also on the remarks of Mr. Weise in the auditor's report:—"No allowance has been made for the depreciation of the steamship, it being considered the vessel is of the full value at which it stands in the accounts." He did not know who considered her of full value. He knew he might be told that she was a special vessel, but no business man would think otherwise than that she could be renewed at from £3,000 to £5,000 less. He therefore did not see the necessity of insuring her at more than her value, and, moreover, by doing so they were breaking the law.

The CHAIRMAN said he had already explained the increase in the expenses of the vessel. She was insured for £21,000, but she cost a great deal more.

Mr. MASON said that Mr. Taylor's remarks might be applied to every shipping company in the country. There was no shipping company whose capital was represented by the value of the ships.

Mr. TAYLOR was understood to say that shipping companies provided for depreciation.

The CHAIRMAN: We believe that this vessel cost a great deal more than she is insured for.

Mr. TAYLOR said he had always understood that nothing had been written off her value.

The CHAIRMAN: We might this year have written off a certain amount from the value of the "Retriever," and put less to reserve.

Mr. TAYLOR: But why insure her at £21,000 when, if that was her cost, I say she could be got for £4,000 less to-day? I do not find fault; I am giving advice.

The CHAIRMAN stated that in case of an interruption it would be to the benefit of the Company to have insured for so much.

Mr. TAYLOR: But the law says that you may not insure a vessel for more than its value.

The CHAIRMAN: It would be a loss to the Company if the vessel were lost.

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Mr. TAYLOR: I think not, as she could be replaced for less.

The CHAIRMAN: We will take what you say into consideration.

Mr. TAYLOR thought that 5 per cent. at least ought to be written off for depreciation of the vessel.

Mr. T. F. CAMPBELL then seconded the motion, which was carried unanimously.

Mr. TAYLOR afterwards expressed his great regret at the death of Mr. Robinson Kendal, the late Chairman of the Company, whose place, however, he was glad to see so ably filled. He had every confidence in the well-being of the Company, provided that political and other matters over which the Directors could have no control did not intervene.

Mr. CAMPBELL said that the Company had been very fortunate in securing the services of Mr. Marshall to fill the vacancy which had been caused by the lamented death of Mr. Kendal. He proposed the re-election of Mr. Marshall and of Mr. Henry Roberts.

Mr. W. E MAC ANDREW seconded the motion, which was carried unanimously.

Mr. MASON then proposed the re-election of the auditor, M. J. Weise (of the firm of Messrs. Turquand, Youngs, and Co.) He was, he said, very glad to have heard the explanation which the Chairman had given as to the item of interest account, which had attracted a good deal of attention on the part of some of the shareholders.

Mr. TAYLOR seconded the resolution, and it was carried unanimously.

On the motion of Mr. MASON, seconded by Mr. TOWLE, a vote of thanks was passed to the Chairman and Directors.

The CHAIRMAN, in reply, said that the Directors would do everything in their power to make the Company prosperous. Having been himself resident on the coast—in fact, having spent the best years of his life on the coast—he was personally acquainted with the localities and with the large majority of the Company's customers. He also knew what kind of business they had, having worked for about 16 years on the coast.

The proceedings then terminated.

The Consolidated Telephone Construction and Maintenance Company (Limited).

Report of the Directors to be presented at the fifth general meeting of the Company, to be held at the City Terminus Hotel, Cannon-street, E C., on Thursday, the 10th June, at 12 o'clock noon :—

The Directors beg to lay before the shareholders a statement of accounts and balance-sheet for the year ending 31st March, 1886. Out of the balance of £5,208. 18s. 4d. remaining to the credit of the revenue account to March 31st, 1885, a dividend of 2½ per cent. was paid to the share holders in June ; and £310 has been paid towards a settlement of the late Directors' fees, which were in abeyance. The gross profits of the year amounted to £13,473. 16s. 2d. After deducting the working expenses, £3.695. 11s. 1d., together with £500 written off goodwill and patents, and £359. 3s. at 10 per cent. depreciation of plant, machinery, and office furniture, there remains a balance of £8,919. 2s. 1d. To this must be added £682. 19s. 7d. balance from the year 1884-5, which makes a total of £9,602. 1s. 8d. Out of this a dividend of 2½ per cent. was paid in November last, amounting to £4,215. 18s. 9d. ; and your Directors now recommend that a further dividend of 2½ per cent. be paid, leaving a balance of £1,170 4s. 2d. to be carried forward to the next year's account. Your Board is happy to state that the relations between the United Telephone Company and your Company continue to be of a most satisfactory nature. Your Directors are pleased to be able to state that the the manufacturing business shows a steady increase, the Company having secured many new customers abroad, in addition to the usual orders from the United Telephone Company. They are also gratified to report that more orders have been given by the United Telephone Company and its subsidiary companies for non-patented articles. This result has been mainly achieved through the improvement in the various articles manufactured by your Company. Agencies have been started in Madrid, Cadiz, and Naples, and it is in contemplation to send a representative to the Continent with a view of opening up fresh ground for the sale of instruments. An amount of £103. 9s. 7d. has been obtained in reduction of income-tax, which was under appeal when the previous accounts were issued, in addition to which the further sum of £187. 18s. 6d., which was reserved in last year's account, pending the appeal, has now been brought to the credit of the year's account, making the £291. 8s. 1d. shown in the present accounts. A compromise has been arrived at with certain of the late Directors in connection with their fees. Sir Alexander Armstrong and Mr. Bigelow have voluntarily relinquished their claims, and the claims of Messrs. Carnegy and Spensley have been settled for the total sum of £310. Colonel Gouraud, notwithstanding the circular sent round by him to the shareholders in July, 1884, stating that he voluntarily relinquished his fees, has commenced an action against your Company for the sum of £1,426 15s., and your Board have instructed the Company's solicitors to defend the action. This leaves Sir Julius Vogel alone unaccounted for, but against this gentleman the Company have a large claim in respect of the allotment of shares at the outset of the Company's history. Your Directors will ask permission to join the Edison-Gower Bell Telephone Company in an action against the Bell Telephone Company of Antwerp and the Compagnie Belge du Telephone Bell. These companies are largely infringing the Edison patent in Belgium, and your legal advisers state that there is a good case against them. The debts due by the subsidiary companies on March 31st, 1885, having been either settled or converted into shares or debentures, estimated by the Directors to be of the full value stated in the balance-sheet, the reserve of £6,000. which has stood in the account of the Company against these assets, is no longer required for this purpose. They have, therefore, with the approval of the auditors, passed this amount to the credit of a reserve fund for the general purposes of the Company. For the present this amount is invested in the general assets. The most important event which has occurred in connection with the subsidiary companies is the signing of a preliminary agreement between the River Plate Telephone Company and the opposing company, the United Telephone Company of the River Plate. The result of an amalgamation after four years' hard fighting cannot be otherwise than beneficial to your Company. The business of the several subsidiary companies in which this Company is largely interested continues to make very satisfactory progress. The Telephone Company of Austria at the end of March, 1885, had 918 subscribers, paying a gross annual rental of £6,433. At the end of March, 1886, there were 1,373 subscribers, representing a gross annual rental of £9,258. This shows an increase of 455 subscribers, and of £2,825 on the annual rental. There also were 172 persons wishing to join the exchanges, with a gross annual rental of about £1,240. These are being connected up as fast as possible. With regard to the Edison-Gower Bell Telephone Company, at the end of March, 1885, the two exchanges of Lisbon and Oporto had 870 subscribers, paying a gross annual rental of £5,380 ; and at the end of March, 1886, there were 1,105 subscribers, paying a gross annual rental of £6,80). This shows an increase of 235 subscribers, and of £1,420 rental during the year. As to the River Plate Telephone Company, on the 28th February, 1885, the number of subscribers to the exchanges of Buenos Ayres and Monte Video was 1,858, with a gross annual rental of £29,400, and on the 28th February, 1886, there were 2,181 subscribers, paying a gross annual rental of £35,107. This shows an increase of 323 subscribers and £5,707 gross income. The total increase in the exchanges, as compared with 1885 and 1835, may therefore thus be stated :—

	Subscribers.	Rental.
Telephone Company of Austria	455	£2,825
Edison Gower-Bell Telephone Company ...	235	£1,420
River Plate Telephone Company	323	£5,707
Total increase for the year.....	1,013	£9,952

In accordance with the Articles of Association the following Directors retire by rotation, and being eligible, offer themselves for re-election, viz., Sir Alexander Armstrong, A. H. Baker, Esq., and H. Grëwing, Esq. The auditors, J. G. Griffiths, Esq., F.C.A. (Messrs. Deloitte, Dever, Griffiths, and Co.), and A. E. Green, Esq., also retire, and offer themselves for re-election.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. JUNE 2.			BUSINESS DONE WEEK ENDING JUNE 2. Highest.		Lowest.
Anglo-American	32,	33½	.....	33½	.....	32¾
Do. Preferred	53,	54	.....	53⅞	.....	53
Do. Deferred	10¾,	11¼	.....	11⅜	.....	10¼
Brazilian Submarine	10⅜,	10⅝	.....	10⅝	.....	10⅜
Cuba	10½,	10⅝	.....	10⅝	.....	10½
Do. Preference	18,	19	.....	—	.....	—
Direct Spanish	1½,	2	.....	—	.....	—
Do. Preference	9,	10	.....	—	.....	—
Direct United States Cable	9,	9½	.....	9 3-16	.....	—
Eastern Telegraph	10⅝,	10¾	.....	10¾	.....	10⅝
Do. 6 per Cent. Preference	14½,	14¾	.....	14¾	.....	—
Do. 5 per Cent. Debentures, 1899 ..	105,	108	.....	—	.....	—
Eastern Extension	12,	12¼	.....	12¼	.....	12
German Union	9½,	9¾	.....	9½	.....	—
Globe Telegraph and Trust	6½,	6¾	.....	6¾	.....	6½
Do. Preference	13½,	13¾	.....	13½	.....	13 3-16
Great Northern	12¾,	13¼	.....	13	.....	12¾
Indo-European	33½,	34½	.....	—	.....	—
Reuter's	6,	6½	.....	—	.....	—
Submarine	200,	210	.....	—	.....	—
West India and Panama	⅝,	¾	.....	—	.....	—
*Do. 1st Preference	8,	8½	.....	8⅝	.....	8½
Western Brazilian	7⅜,	7⅝	.....	7⅝	.....	7 1-16
Western Union 7 per Cent. 1st Mortgage	118,	122	.....	—	.....	—
Do. 6 per Cent. Sterling Bonds.....	103,	107	.....	—	.....	—

TELEPHONES.

Consolid. Telephone and Maintenance..	13-16	15-16	.....	—	.....	—
Oriental	3-16	5-16	.....	—	.....	—
United Telephone	13½,	13⅝	.....	13⅝	.....	12¾

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)..	2½,	2¾	.....	—	.....	—
Do. (fully paid)	4½,	4¾	.....	—	.....	—
Swan	1⅜,	1⅝	.....	1⅞	.....	1½
Maxim-Weston	3-16	5-16	.....	—	.....	—

MISCELLANEOUS.

Telegraph Construction	37½	38½	.....	37½	.....	37½
India Rubber, Gutta Percha, and Telegraph Works	23	24	.....	23½	.....	23

* x.d. 6s. on account of arrears.

TRAFFIC RECEIPTS FOR MAY, 1886

COMPANIES.	May, 1886.		May, 1885.		Increase.		Decrease.
Direct Spanish Telegraph ..	1,688	....	1,352	....	336	....	—
Eastern Extension	41,037	....	50,016	....	—	....	8,979
Eastern Telegraph	50,741	....	61,327	....	—	....	10,586

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NOTES.

MR. CYRUS W. FIELD.—This gentleman is a passenger by the "Umbria," which left New York for Liverpool on Tuesday.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 4th inst amounted to £2,660.

PHYSICAL SOCIETY.—A paper by Mr. W. Emmott and Mr. W. Ackroyd, on electric fire damp indicators, is announced for reading on Saturday, June 12.

THE OLD TELEGRAPH COMPANIES.—The annual social gathering of officers of the old Telegraph Companies took place at the Mitre, Hampton Court, on Wednesday last.

FINSBURY TECHNICAL COLLEGE.—We are informed that the students of the Finsbury Technical College intend holding their second annual *conversazione* on the evening of July 2.

PERSONAL.—Mr. W. H. Fleming, late of Baliol-chambers, has been appointed manager of the electrical department of Messrs. Marshall and Co., Custom House-arcade, Liverpool.

SOCIETY OF ARTS.—The *conversazione* of this society will be held, by permission of the Royal Commission, at the Colonial and Indian Exhibition, South Kensington, on Friday, the 16th of July.

PARIS.—According to the *Bulletin International de l'Electricité*, MM. Siemens have decided to close their works in Paris. The business will be carried on direct from one of the other houses of this firm.

AN ELECTRICAL MONOPOLY.—The Mexican *Diario Official* publishes a decree granting an exclusive privilege for ten years to Messrs. E. H. and A. H. Cowles for their process of reducing metals by electricity.

GREAT NORTHERN TELEGRAPH COMPANY.—The receipts of this company in May were £22,480, and the receipts for the period of January to the 30th May, £100,960; for the corresponding months in 1885 £118,000, and 1884 £106,560.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending 4th June were £2,093, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

ROYAL SOCIETY.—At the second *soirée* of this society, held on Wednesday last, the telephone room was put into communication with the Savoy Theatre, and a large supply of instruments were provided for hearing the performance of "The Mikado."

BOOKS RECEIVED.—"Electric Transmission of Energy." By Gisbert Kapp. London: Whittaker and Co. and George Bell and Sons.—The second edition of "Traité Practique d'Electricité Industrielle," par MM. Cadiat et Dubost. Paris: Baudry et Cie.

EARTHQUAKES.—Several shocks of earthquake have been felt lately in the island of Chios and in the Erythrian Peninsula, but no damage has been done.—A smart shock of earthquake was felt in Guernsey on Monday last. Buildings in different parts of the island were shaken.

CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this company during the month of May was 3,744, estimated to produce £3,050, against 4,474 messages, producing £3,736 in the corresponding month of last year. The traffic receipts for the month of February, estimated at £2,750, realised £2,771.

MONTPELIER.—A company has recently been formed in Montpelier, under the name of the Standard Light and Power Manufacturing Company, having for its object the furnishing of electric light for places of business in the town and such private houses as can be reached. We understand that an exhibition of electric light will shortly be made at Montpelier.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The directors of this company on Wednesday last declared an interim dividend of 3s. per share, or at the rate of 6 per cent. per annum, free of income-tax, for the quarter ended March 31st, 1886, payable on the 24th inst. The books of the company will be closed from the 17th to the 23rd inst., both days inclusive.

CONVENIENCE AND INCONVENIENCE.—Even in India, where one would have thought the requirements of the military were almost supreme, it does not always happen that their desires are consulted, for we find that a telegraph office has been opened in the native city of Aurungabad, about two miles from the military cantonment, much, it is said, to the inconvenience of the military element.

COPPER WIRE FOR TELEPHONES.—The Central District and Printing Telegraph Company, which controls the Bell telephone patents in Western Pennsylvania, is making some important changes in its lines of wire. At present it is replacing some 200 miles of wire throughout Pittsburg with a hard copper No. 14 wire that costs $25 a mile. The iron wire that is being removed cost $9 a mile.

ELECTRICITY IN MEDICINE.—It is interesting to note how largely electrical appliances are being used in the medical profession. Constant readers of the *Lancet* will not fail to see week by week discussions as to the best methods of using electricity in surgical and in medical cases. We believe there exists a widespread belief among the profession that a grand future exists for electricity in the alleviation of suffering.

ELECTRIC LIGHTING ACT AMENDMENT.—After an exhaustive inquiry, the Select Committee of the House of Lords appointed to consider the three Bills introduced for the purpose of amending the Electric Lighting Act of 1882 have resolved to recommend the adoption, subject to certain modifications, of the measure brought in, on behalf of the Board of Trade, by Lord Houghton. The Bills of Viscount Bury and Lord Rayleigh are thrown out. The full text of Lord Houghton's Bill will be found in another column.

ELECTRIC LIGHT ON STEAMERS.—The General Trans-Atlantic Company of France have constructed specially for its service between Havre and New York four new express packets, all of which are lighted by electricity. Each vessel is provided with 620 incandescent lamps fed by two large dynamos with compound motor, and passengers may in their cabins turn off and on the light at pleasure. To guard against any accident during the voyage a spare dynamo and motor are kept in readiness.

THE ELECTRIC LIGHT AT LE CONSERVATOIRE DES ARTS-ET-METIERS.—This institution has been illuminated recently by the electric light. The installation, which has been carried out under the direction of M. Gustave Tresca, consists of 10 arc lamps of the well-known Cance system, which are distributed as follows:—6 in the library, 3 in the amphitheatre, and 1 in the machine room. This important change in the lighting of the building has been much appreciated, especially by the frequenters of the library.

THE UNITED TELEPHONE COMPANY.—The directors of this company, subject to audit and after making provision for

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depreciation, &c., recommend a dividend for the half year ended the 30th of April at the rate of 9s. per fully paid share, part-paid shares receiving in proportion, making with the interim dividend paid on the 13th of November a total for the twelve months of 13 per cent. per annum, carrying forward a substantial sum to reserve.

TELEGRAPHING EXTRAORDINARY.—The total number of private telegraph messages sent out from the House of Commons during Monday's sitting was 1,387. There were, besides, some 308 Press messages. The total number of messages received during the day for members of Parliament was 395. Between half-past one and half-past two on Tuesday morning, when the division on the Home Rule Bill took place, more than 770 messages were despatched from the telegraph office at the House of Commons.

ELECTRIC LIGHTING IN A POWDER MAGAZINE.—For the last twelve months the powder magazine at Toulouse has been provided with the electric light, which has given the greatest satisfaction. The installation consists of a hundred incandescent lamps (Edison) conveniently distributed over the works, one Mondos arc lamp being erected in the yard. A hydraulic motor is used to work the Siemens dynamos, which send the electric current through underground wires enclosed in earthenware pipes, thus obviating the possibility of any accident.

THE "VICTORIA."—Messrs. Henry Bennett and Co., of Bothwell-street, Glasgow, have secured the lighting of the new passenger saloon steamer "Victoria," launched recently from the yard of Messrs. Blackwood and Gordon, Port Glasgow. This steamer has been built to the order of Capt. Campbell, of Wemyss Bay, and when finished will rank as one of the finest saloon steamers on the Clyde. Capt. Campbell deserves the credit of being the first to light his steamer throughout with the electric light. We have no doubt the other steamboat owners will follow Capt. Campbell's lead in this matter.

THE ELECTRIC LIGHT IN HOSPITALS.—A fresh proof of the growing popularity of the electric light in Paris is to be found in the fact that some interesting experiments are just now being made to light the hospitals there by electricity. A few of these institutions have already been furnished with an installation of incandescent lamps, not only in the operating theatres but in the sick wards, with such satisfactory results from a hygienic point of view that there is little doubt that before long the system will be generally adopted by the *Administration de l'Assistance publique.*

ELECTRICAL TRANSMISSION OF POWER.—The Cannon Foundry at Bourges has two 20-ton cranes for the handling of very large ordnance. Each of these is worked by a special electrical motor, with current furnished by a single generator. The power is transmitted a distance of 120 metres, and is about 13 horse-power out of 25 horse-power. The working has always been effected without accident. In the same establishment there has also been employed, since the year 1879, two Gramme dynamos, one as a generator, the other as receiver for the testing of metals by means of a traction machine.

SHIP LIGHTING BY INCANDESCENCE.—The "Prince Albert" (1,062 tons B.M.), launched by the Cockerill Company at Antwerp on Wednesday week, is the first of a series of steel packets, built for the Belgian Government, for the mail service between Dover and Ostend, to have a stipulated speed of at least 17½ knots at sea. The vessel is to be lighted throughout by 90 incandescent lamps of varying intensity (16, 20, 30, and 50 candles); and also to be provided with two mast lights for lighting up the deck while passengers are going on board or on shore, to be extinguished the moment the steamer leaves her moorings. Each of these lights will consist of eight 50-candle incandescent lamps.

THE ELECTRIC LIGHT IN SHIPBUILDING.—A very happy and novel application of the electric light has been successfully effected in the shipbuilding yards of Lorient. Hitherto the interior of vessels during their construction has been in a state of almost complete darkness, the *employés* having to ply their various crafts by means of candlelight, a condition of things which left much to be desired in point of illumination. At the request of the engineers of naval constructions, MM. Sautter, Lemonnier, and Co. have just executed an installation of electric incandescent lamps, which can be moved about from place to place at will, just as candles, but of course being of infinitely greater illuminating power. The experiment has given the greatest satisfaction to the workmen.

THE CONVENTION OF ROYAL BURGHS AND THE TELEPHONIC SYSTEM.—At the recent annual meeting of the Convention of Royal and Parliamentary Burghs it was resolved to urge Government to acquire by purchase the telephonic system, and to work the same as a branch of the postal service. Mr. Officer, S.S.C., agent of the Convention, received on Monday a letter from the Postmaster-General acknowledging receipt of the communication, and saying:—"Lord Wolverton cannot but attach great weight to a recommendation coming from such a body as the Convention, and I am to say that the matter, which involves questions of importance and difficulty, shall receive his very attentive consideration.—I am, sir, your obedient servant, S. A. Blackwood."

THE SUEZ CANAL.—In the report which M. de Lesseps read before the shareholders of the Suez Canal Company in Paris on Tuesday it was stated that during the last two years the company has been making experiments with the electric light, with a view to enable vessels to continue their course through the canal by night. Those experiments having led to most favourable results, the company issued a notice on 3rd November authorising ships of war and postal steamers to continue their course during the night by the aid of the electric light in that portion of the canal comprised between Port Said and Kilomètre 54. Several of the Peninsular and Oriental Company's steamers have already availed themselves of that authorisation, and their navigation in the canal by night has proved a complete success.

WESTERN UNION.—The following remarks are made by the correspondent of the *Standard* upon the report just issued:—The omission of a declaration of a quarterly dividend has caused no surprise. The official report accompanying the announcement attributes the decrease in the revenue compared with the estimate to the payment of disputed taxes to the amount of one hundred and ninety-three thousand nine hundred and thirty-three dollars, which the company says the New York authorities must refund. The general business is declared to be unusually good, but it is off-set by the decreased revenues from the cables from the news service. The entire surplus, together with the last scrip dividend, has gone into plant, which can be distributed as stock or bonds, whichever is thought most expedient.

GOVERNMENT MONOPOLY OF THE TELEPHONE IN SPAIN.—The advisability of continuing the telephone system in Spain under Government control is reported to be under the consideration of the Minister of the Interior. About two years ago Señor Robledo, who was then Minister of the Interior, on

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the pretext that it would be dangerous to allow the telephone service to be in the hands of a private company, monopolised it for the State. Two years of an expensive service for the public has resulted in a proposal to abandon the system; but, according to *El Dia*, the proposal is to grant a concession to a private individual, which, it is argued, would not result in any increased advantage to the public. It is urged that the telephonic service should be thrown open to the public free of privileges of any description. The contention with the gas company of Madrid (to which we refer in another column) is alluded to as an example of the evil effects of monopolies.

EXHIBITION IN PARIS.—We are informed that an international exhibition has been organised by the *Société National des Sciences and Arts Industriels* to be held in the Palais de l'Industrie. The exhibition will open on the 24th of July, remaining open till November. In the circular relating to the same it is said that since the exhibition of 1881—of which the results were very important regarding the industries connected with the general appliances of electricity, and particularly of the electric light—considerable progress has been made. The proposed exhibition, although it may not be so important as that of 1881, is expected to contain a very large number of interesting exhibits. The electric lighting department is under the direction of M. H. Fontaine. The promoters of this exhibition have thought that this year forms a medium period between the exhibition of 1881 and the proposed universal exhibition in 1889, and they hope the exhibits will show the progress that has been made during the last few years.

THE LIGHTING OF MADRID.—*El Dia* states that a second meeting was held in the Madrid Mercantile Club on Friday night last of the committee and representatives of the trading community appointed to arrange for the lighting of the city. It was stated that Messrs. Edison would not be able to complete the installation of the electric light before the month of October next. It was nevertheless decided to adhere to the original decision to completely abstain from the use of gas for lighting purposes as from the 1st July next, and to make arrangements in the meanwhile to substitute some other mode of lighting pending the installation of the electric light. The light recommended by the committee to be thus used temporarily is a gasoline light on the Wilhelm system. In reply to a question it was stated that the decision referred to does not preclude the use of gas as a motive power. The unanimity exhibited on this question appears to be due to the belief that in fighting the Gas Company a blow is being struck at the system of monopolies which are said to weigh heavily on the trade of the city.

ELECTRIC LIGHT IN PARIS.—The lighting of the Parisian theatres by means of electricity, which has been under consideration for a considerable time, is now about to be practically carried out. La Société Electro-Mecanique has undertaken to establish in the quarter of the Porte-Saint-Martin a central station, to provide the light to the numerous places of amusement in that busy part of the French capital, notably the theatres de la Renaissance, de la Porte-Saint-Martin, de l'Ambigu, des Folies-Dramatiques, du Château-d'Eau, de la Gaîté, des Menus-Plaisirs, du Gymnase, not to mention the concert rooms de l'Alcazar, de la Scala, Parisien, &c. The installation will doubtless be extended to the theatres des Variétés, and to some of the numerous restaurants and cafés which abound in the neighbourhood. Experiments will also shortly be made at the Théâtre Français, where the temperature has been hitherto rendered well nigh insupportable in consequence of the heat generated by the numerous gas lights, with the object of substituting the electric light for the rival illuminant.

EDINBURGH EXHIBITION. — Messrs. Andrews and Co. are lighting the machinery in motion section and the Old Edinburgh-street of the Exhibition with 33 Andrews arc lamps, which are connected in parallel circuits to two pairs of mains, one carrying 16 lamps, and the other 17. Each section of lamps is connected to a separate Andrews dynamo, but the main wires are arranged so that the whole of the lamps can be run from one of the machines. Throughout the department the neighbouring lamps are on alternate circuits, and are arranged to produce the best illumination of the exhibits; each light having a current of 25 amperes there is an abundance of light. The Old Edinburgh-street is lighted with one powerful lamp suspended from a pole above the buildings, which casts a moonlight effect into the street. The machines working these lamps are Andrews' well-known slow-speed dynamos, one a large machine, weighing 3½ tons, and capable of maintaining nearly double the whole number of lamps, running at a speed of 290 revolutions per minute, and the other a 35 unit machine, running at 400 revolutions per minute.

BURMAH.—In addition to our note of May 21, the following further information about the telegraph department in Burmah has recently been published:—"There has been some delay in the progress of telegraphic communication in consequence of the unsettled state of the country at present. The lines and offices have been made a special division in charge of a superintendent, who has under him four assistants and four sub-assistants, besides a large staff of trained signallers. All the labour in the way of coolies, some 200 or 300, is taken from Rangoon, and the work proceeds as rapidly as possible, seeing that escorts cannot always be obtained, and that the work is not allowed in many parts to be carried on without a military escort. Arrangements have been made for a line to Bhamo as soon as this protection can be afforded; another, between Mingyan and Yemethen, has been stopped because this is not forthcoming. It is proposed to connect Rangoon and Mandala by two lines, one running up by the river, and the other *via* Ningyan and Tounghoo. A line between Hymgyan and Yemethen will shortly be undertaken, as there is already a second line between Mandalay and Myingyan, and this will form part of the alternative line from Mandalay to Rangoon."

THE BELL TELEPHONE PATENTS.—It is now more than ten years, says the *Electrical World*, since a patent was granted to Alexander Graham Bell that has given rise to more controversies in the courts and the press than any other patent ever issued. The documents, arguments, and evidence in the various suits, and the books and pamphlets on the subject, would constitute a good-sized library. It is needless to enter into all the details of the points raised by the suit. They may be summarised as follows:—1. That Bell is not the original inventor of the speaking telephone, being anticipated by Reis, Dolbear, Gray, Meucci, Hughes, Varley, Edison, Boursel, and others. 2. That the patent No. 174,465 was obtained from the Patent Office by fraud. 3. That the same patent does not describe an operative instrument for transmitting speech, and hence is void. Fig. 7 is alleged to show an instrument that will not talk. 4. That undulatory current such as is described in the fifth claim of the same patent is not necessary to the transmission of articulate speech; and that if it be essential thereto, it constitutes a *principle*, which cannot be patented. 5. That the magneto-telephone now used as a receiver by the American Bell Company is Dolbear's, and that patent No. 186,787 is therefore invalid, said invention being communicated to Bell by a friend of Dolbear, and the latter being then

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misled as to the fact of his own priority. These and other points will be brought out prominently at the trial of the suit. The Bell Company is understood to be of opinion that it has met one and all of them successfully in the many suits through which it has already passed without a single defeat.

THERMO-ELECTRICITY.—MM. Pilleur and E. Jannetaz, according to the *Journal de Physique*, have endeavoured to ascertain if, when a given point of a conductor is heated having a schistous texture, thermo-electric currents are produced in it. Then experiments extended to zinc, tin, iron, and copper. The schistous or long-grain texture was imparted to them by carefully drawing out. A point, A, at the centre of the plate is heated and one contact is made on the other side of the plate, at the end of the line which connects this point with A *across the long grain*, the other taken at a point, C, on the end of the line joining the point A *along the long grain*. In all cases a current was obtained from B to C. The strength of the current for the same metal appeared connected with the development of the *long grain*. Thus, that zinc which had passed four times through the draw-plate gave a feebler current than zinc which had been drawn out six times. But copper with a good deal of long grain, that is much more fragile in one direction than another, gave a feebler current than tin, which seemed to have no appreciable grain. It must, moreover, be observed that this tin had passed six times through the plate; hence the thermo-electric action shows the action of the draw-plate, even when the fracture does not show it. The strongest currents were shown by zinc, and the feeblest by copper. The currents are, however, difficult to observe, doubtless owing to the facility with which they unite across the plates themselves. More powerful effects may be obtained by cutting a knee-piece in the metal-plate, in one branch of which the long grain is across and in the other in the direction of the length, and then joining the two ends of the knee-piece to the external circuit.

THE ELECTRIC LIGHT IN MINES.—The coal pit St. Theodore of what is known as the coalfield Sacré-Madame (Belgium) has for the past two years been lighted by electricity. The installation comprises two arc lamps of 2,000 candle-power in the sorting shed and yard, and thirty Swan incandescent lamps of 20 candle-power in the various buildings. The motive power is supplied to the Gramme dynamos by a small engine of the Robey type, furnished with a regulator with centrifugal action. Since the 25th of January, 1884, the date when the installation was put in operation, up to the 15th of January, 1885, the expenses of every kind in connection with it (salaries, coal, oil, lamps, pencils, repairs of machines, &c.) have amounted to 1,859f., whilst for thirty gas burners, taking their average cost at other pits, the outlay has been 6,544f. The economy effected by substituting electricity for gas is therefore very appreciable. Moreover, thanks to the greater illuminating power of the electric light, coal can be, under these altered conditions, sorted and purified at night as well as during the daytime. Another advantage is that the workmen are enabled to pursue their avocations as many hours throughout the winter as they are throughout the summer months. The average duration of the incandescent lamps is 587 hours per lamp. Out of the thirty lamps first installed there remain nine in use, of which three lasted to the 25th of January, 1885, thus reaching the remarkable figure of 3,451 hours. The mean duration of these 30 lamps up to that date was therefore 760 hours. These results are exceedingly satisfactory, and augur well for the future application of electric lighting to this important industry. The *Mouvement Industrial Belge*, from which we extract the preceding details, says that as the result of this emphatic proof of the advantages of the electric light, the directorate of this large coalfield have decided to illuminate the whole of the pits with the electric light.

PROGRESS OF INDUSTRIAL ELECTRICITY.—"How was that made?" This question was asked of a prominent metal merchant as a vessel was handed him, made in the shape of a head-light reflector. It was composed of copper about one sixty-fourth inch thick, tough, pliable, and very smooth on the inner surface. Examining the edges of the flange, the merchant noticed that the thickness of the metal did not vary in the least around the entire rim. "It was spun?"—"No." "Stamped?"—"No." "Pressed?"—"No." "Cast? Impossible!"—"No, it was not cast." "Then it must have grown." It had grown, but it was with the rapidity that only electricity can give to growth. The process by which the above casting or vessel was made is as follows:—A rigid male form is made of the approximate shape and less in size than the article wished to be reproduced. This form is then immersed in a kettle of refined wax, paraffin, or similar substance. The shape of form will decide in what position the form is to be held; in the case of a reflector the form is held with small end up. The way must be pure and free from dirt or water to get best results. The wax is heated so that it will run nicely. By immersing form in kettle and withdrawing vertically, the wax will run smoothly, and as it cools in a few seconds leaves a smooth, true surface. This surface is now rendered conductive with the well-known electrotyper's process, by the application of black lead, iron filings, and blue vitriol. The whole thing is then immersed in a copper solution, and connected electrically with a dynamo. Copper anodes are also put in solution, and connected electrically with opposite pole of dynamo. The dynamo is set in motion, and the "growth" of a vessel begins. The thickness of vessel is dependent upon the length of time deposit is allowed to continue; pieces of copper an inch thick have been made. The time required to make a vessel of a certain weight and size depends altogether upon the size of the dynamo. The perfection and strength attained by these "electric engines" through the perseverance of recent inventors and manufacturers is something marvellous.—*Electrical World.*

SHIP LIGHTING.—The electric light has for some time asserted its supremacy over all competitors in the immense passenger steamers turned out from the Clyde, and it is now beginning to obtain a strong foothold on much smaller vessels. The "Alejandro," a small yacht-built steamer of about a thousand tons, just finished by the Sunderland Shipbuilding Company, and intended for the Mexican passenger coasting trade, has been fitted throughout with the electric light, to the total exclusion of oil. The number of 18 candle-power incandescent lamps is seventy-five, two deck clusters of twelve lamps each being supplied for use when discharging cargo. The whole of the work was carried out by Messrs. Dorman and Smith, of Manchester. The same firm has also been entrusted with the contract for lighting the "Euterpe," a fine passenger steamer now building for the Austro-Hungarian Lloyd's by Messrs. J. L. Thompson and Sons, of Sunderland.—Messrs. Andrews and Co. have just completed an installation of about 100 lights on board the ss. "Dynamic," which has been under alteration by Messrs. Workman Clark and Co., of Belfast. The current is supplied by one of Andrews' patent dynamos, running at a speed of 500 revolutions per minute. The light has been distributed throughout every portion of the ship with the exception of the signal lamps. Two clusters (portable) of three 50 candle-

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power lamps each are used to light the hatches when loading or discharging cargo. The fittings throughout have been manufactured by Messrs. Andrews and Co., and are of a thoroughly substantial character and admirably suited to their various positions. The light in the saloon is especially brilliant, and the handsome nickled fittings give it a very effective appearance. One particular which is worthy of note is the despatch with which the electrical outfit has been completed, the vessel having only been laid up for a fortnight, and the trial of the electric light having been made, with the most satisfactory results, the night before she left the dock. Besides this work Messrs. Andrews and Co. have just completed the electric lighting of the second of three Atlantic steamers for the North German Lloyd's.

THE "COLOSSUS."—Last Saturday, in response to an invitation from Lord Charles Beresford, about 150 members of Parliament and a number of other distinguished visitors left London for Portsmouth in order to witness a modern naval sham fight. One of the most interesting of the vessels engaged in this fight was the "Colossus," of which the following interesting note is given by the *Daily Telegraph* correspondent :— "The 'Colossus' is really more a mighty floating steel battery than a ship. She is a steel-armoured vessel of over 9,000 tons burthen, with double turrets and twin screws. She is short and broad, being about 350ft. long and 68ft. beam. She is furnished with electrical apparatus for incandescent lamps to light the ship, and for arc lights to guard against attacks by torpedo boats. Her armament consists of four 43-ton guns, similar to the pattern now considered unsafe, five six-inch breechloading cannon, and a number of quick-firing Hotchkiss, Nordenfelt, Gardner, and other guns, and torpedoes. The hydraulic machinery working the turret and the 43 ton guns was shown in motion. The 43 ton guns are ranged side by side like big reversed binocular glasses. Shotted and fired together, as they can be, each hurling its 714lbs. of shot with a punching power than can pierce over 20in. of solid iron at 1,000 yards, they would deliver an awful double-handed blow at an enemy. Below deck the 'Colossus' has passage ways as tortuous, narrow, and bewildering as Egyptian catacombs. Were the electric light to fail and none other available, it would be well-nigh impossible to find one's way back to daylight. The engine room had a tropical heat, and it was said that the stokehole, when in full blast, must be a veritable oven. In the electrical machinery room the thermometer on Saturday stood at 116 deg. Fahr., and the workmen were as lightly clad and as warm apparently as sugar-house *employés*. That electrical room has been a boon to Portsmouth watchmakers, for every watch taken therein is lost. Not actually filched out of the pocket, but quite as bad. Electricity lays hold of the steel parts of the watch in less time than it takes to write about it, makes magnets of them, and for ever thereafter the hours come and go upon the dial in the most eccentric and unreliable way. The officers and crew of the 'Colossus' have ruined scores of watches by wearing them in that room. Subsequently tea was served in the officers' quarters to the visitors. After a most agreeable hour the party returned to the tugs and steamed back to Portsmouth, when the 'special' train conveyed them to London, which was reached about 7:30 p.m. There was but one opinion expressed, and that was that the day had been extremely pleasantly and profitably spent. The trip brought out in a large degree what the might and responsibility of Empire in some measure mean, and the general wish was expressed that others, and especially our colonial brethren and visitors, should participate occasionally in such visits to one or other of the great Government establishments."

TELEPHONY.—M. Rothen continues in the last number of the *Journal Télégraphique* the statistics relating to telephony. M. Rothen's previous communication will be found p. 509 of our issue of May 7 last :—

The United States.

Towns.	No. of Subscribers.	Population.	Population per Subscriber.	Subscription in Francs.
New York	9,000	1,206,209	134	315—976
Chicago	3,630	503,184	139	525—787,50
Buffalo	3,200	155,134	48	...
Philadelphia.	3,000	847,170	282	630
Cincinnati	2,700	255,130	94	262,50—787,50
Brooklyn	2,354	566,663	241	500
Providence	2,250	104,857	47	220,50—315
Boston	2,100	362,535	173	378—761,25
Detroit	2,025	116,340	57	378
San Francisco	2,017	233,956	116	315
Pittsburg	1,700	247,765	146	550
Baltimore	1,981	332,313	168	500
Cleveland	1,685	160,146	95	360
St. Louis	1,528	350,518	229	500
Milwaukee	1,380	138,523	100	—
Kansas City.	1,250	55,813	45	—
Washington..	1,234	147,307	119	—
New Orleans	1,000	216,140	216	—
Albany	1,200	155,044	129	—
Indianapolis.	1,025	75,074	73	—
Evansville	600	25,835	43	—
Atlanta	550	10,445	19	—
Erie	317	27,000	85	—

In the United States the number of exchanges is 752, of stations 151,056, of *employés* 5,700, and the length of the wires is 138,207 kilometres. A capital of 500 million francs is employed. In 1884 the gross receipts amounted to 47,500,000fr., and the expenses to 30,250,000fr. Our statistics are somewhat incomplete, and relate to some of the most important exchanges. At Buffalo each "conversation" costs from 20 to 30 centimes (according to the number of "conversations" held) annually—a principle appreciated by the public. The exchange of Philadelphia is in communication with 42 other central offices.

Position of Telephonic Exchanges of the United States on the 31st December, 1882-1885.

	1882.	1883.	1884.	1885.
No. of Central Stations.	725	906	764	752
Kilometres of wire on poles	—	—	142,366	161,914
Ditto roofs	—	—	19,125	16,169
Ditto underground	—	—	1,971	5,516
Ditto submarine	—	—	—	425
Total length kilometres.	110,331	138,207	163,462	184,024
Number of subscribers	97,728	123,625	134,601	137,570

The Antilles.

Towns.	No. of Subscribers.	Population	Population per Subscriber.	Subscription in Francs.
Havanna	356	230,000	646	—
Port of Spain	190	—	—	—
Bridgetown	175	36,000	206	—
Kingston	76	35,000	461	—

Mexico.

Mexico	643	241,110	375	—
Guadalajara	171	91,685	536	—

Mexico has in all 17 exchanges, with a total of 3,200 subscribers.

Venezuela.

La Guayra	800	—	—	—
Caracas	475	48,897	103	—
Valencia	150	29,000	193	—
Porto-Cabello	125	8,000	64	—

Brazil.

Rio de Janeiro	1,675	310,000	184	—
Pernambuco	275	116,671	424	—
Bahia	215	128,929	526	—
Campanas	145	—	—	—
Santos	135	7,100	53	—

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ELECTROMAGNETIC INDUCTION AND ITS PROPAGATION.—XXVII.

BY OLIVER HEAVISIDE.

(Continued from page 9.)

The Variable Period in a Round Wire with a Concentric Tube at any Distance for the Return Current.

The case considered in the last section was an extreme one of departure from the linear theory. This arose, not from mere size, but from the closeness of the return to the main conductor, and to its completely enclosing it. Practically we must separate the two conductors by a thickness of dielectric. The departure from the linear theory is then less pronounced; and when we widely separate the conductors it tends to be confined to a small portion only of the variable period. The size of the wire is also then of importance.

Let there be a straight round wire of radius a_1, conductivity k_1, and inductivity μ_1, surrounded by a non-conducting dielectric of specific capacity c and inductivity μ_2 to radius a_2, beyond which is a tube of conductivity k_3, and inductivity μ_3, inner radius a_2 and outer a_3. The object of taking c into account, temporarily, will appear later.

Let the current be longitudinal and the magnetic force circular. Then, by (1*b*), if γ is the current density at distance r from the axis, we shall have

$$\frac{1}{r}\frac{d}{dr}\,r\,\frac{d\gamma}{dr}=4\pi\mu k\dot{\gamma},\qquad \text{or}=c\mu\ddot{\gamma},\quad .\ .\ .\quad (18b)$$

in the conductors, and in the dielectric respectively; the latter form being got by taking $\gamma=c\dot{\mathrm{E}}/4\pi$, the rate of increase of the elastic displacement.

A normal system of longitudinal current density may therefore be represented by

$$\left.\begin{aligned}\gamma_1&=\mathrm{A}_1\mathrm{J}_0(n_1r), && \text{from } r=0 \text{ to } a_1\\ \gamma_2&=\mathrm{A}_2\mathrm{J}_0(n_2r)+\mathrm{B}_2\mathrm{K}_0(n_2r), && \text{,, ,, } a_1\text{,, } a_2\\ \gamma_3&=\mathrm{A}_3\mathrm{J}_0(n_3r)+\mathrm{B}_3\mathrm{K}_0(n_3r), && \text{,, ,, } a_2\text{,, } a_3\end{aligned}\right\}.\quad (19b)$$

in the wire, in the insulator, and in the sheath, respectively, at a given moment. In subsiding, free from impressed force, each of these expressions, when multiplied by the time factor ϵ^{pt}, gives the state at the time t later.

$\mathrm{J}_0(nr)$ is the Fourier cylinder function, and $\mathrm{K}_0(nr)$ the complementary function. (For their expansions see *The Electrician*, Aug. 23, 1884, p. 328, equations (70) and (71)). The A's and B's are constants, fixing the size of the normal functions; the n's are constants showing the nature of the distributions, and p determines the rapidity of the subsidence.

By applying (18*b*) to (19*b*) we find

$$n_1^2=-4\pi\mu_1k_1p,\quad n_2^2=-\mu_2cp^2,\quad n_3^2=-4\pi\mu_3k_3p\,;\ .\quad (20b)$$

expressing all the n's in terms of the p.

Corresponding to the expressions (19*b*) for the current, we have the following for the magnetic force:—

$$\left.\begin{aligned}\mathrm{H}_1&=-(n_1/\mu_1k_1p)\mathrm{A}_1\mathrm{J}_1(n_1r),\\ \mathrm{H}_2&=-(4\pi n_2/\mu_2cp^2)\{\mathrm{A}_2\mathrm{J}_1(n_2r)+\mathrm{B}_2\mathrm{K}_1(n_2r)\},\\ \mathrm{H}_3&=-(n_3/\mu_3k_3p)\ \{\mathrm{A}_3\mathrm{J}_1(n_3r)+\mathrm{B}_3\mathrm{K}_1(n_3r)\},\end{aligned}\right\}.\quad (21b)$$

where, as is usual, the negative of the differential coefficient of $\mathrm{J}_0(z)$ with respect to z is denoted by $\mathrm{J}_1(z)$; and, in addition, the negative of the differential coefficient of $\mathrm{K}_0(z)$ with respect to z is denoted by $\mathrm{K}_1(z)$. These equations (21*b*) are got by the second and third equations (1*b*), in the case of H_1 and H_3; and in case of H_2, by using, instead of Ohm's law, the dielectric equation, giving

$$\mathrm{E}=4\pi\gamma/cp,$$

in the dielectric, E being the electric force. Of course $d/dt=p$, in a normal system.

We have next to find the relations between the five A's and B's, to make the three solutions fit one another, or harmonise. This we must do by means of the boundary conditions. These are nothing more than the surface interpretations of the ordinary equations referring to space distributions. In the present case the appropriate conditions are continuity of the magnetic and of the electric force at the boundaries, because the two forces are tangential; the conditions of continuity of the normal components of the electric current and of magnetic induction are not applicable, because there are no normal components in question. If the magnetic or the electric force were discontinuous, we should have electric or magnetic current sheets.

Thus H_1 and H_2 are equal at $r=a_1$, and H_2 and H_3 are equal at $r=a_2$. These give, by (21*b*),

$$(\mathrm{A}_1n_1/\mu_1k_1p)\mathrm{J}_1(n_1a_1)=(4\pi n_2/\mu_2cp^2)\{\mathrm{A}_2\mathrm{J}_1(n_2a_1)+\mathrm{B}_2\mathrm{K}_1(n_2a_1)\},\quad (22b)$$

and

$$\begin{aligned}&(4\pi n_2/\mu_2cp^2)\{\mathrm{A}_2\mathrm{J}_1(n_2a_2)+\mathrm{B}_2\mathrm{K}_1(n_2a_2)\}\\ &\quad=(n_3/\mu_3k_3p)\{\mathrm{A}_3\mathrm{J}_1(n_3a_2)+\mathrm{B}_3\mathrm{K}_1(n_3a_2)\}.\quad .\quad (23b)\end{aligned}$$

Similarly, E_1 and E_2 are equal at $r=a_1$, and E_2 and E_3 are equal at $r=a_2$. These give, by (19*b*),

$$(\mathrm{A}_1/k_1)\mathrm{J}_0(n_1a_1)=(4\pi/cp)\{\mathrm{A}_2\mathrm{J}_0(n_2a_1)+\mathrm{B}_2\mathrm{K}_0(n_2a_1)\}\ .\quad (24b)$$

and

$$\begin{aligned}&(4\pi/cp)\{\mathrm{A}_2\mathrm{J}_0(n_2a_2)+\mathrm{B}_2\mathrm{K}_0(n_2a_2)\}\\ &\quad=k_3^{-1}\{\mathrm{A}_3\mathrm{J}_0(n_3a_2)+\mathrm{B}_3\mathrm{K}_0(n_3a_2)\}\quad .\quad .\quad (25b)\end{aligned}$$

Thus, starting with A_1 given, (22*b*) and (24*b*) give A_2 and B_2 in terms of A_1, and then (23*b*) and (25*b*) give A_3 and B_3 in terms of A_1. Similarly we might carry the system further, by putting more concentric tubes of conductors and dielectrics, or both, outside the first tube, using similar expressions for the magnetic and electric forces; every fresh boundary giving us two boundary conditions of continuity to connect the solution in one tube with that in the next. But at present we may stop at the first tube. Ignore the dielectric displacement beyond it, *i.e.*, put $c=0$ beyond $r=a_3$, because our tube is to be the return conductor to the wire inside it. We may merely remark in passing that although when such is the case, there is, in the steady state, absolutely no magnetic force without the tube, yet this is not exactly true in a transient state. To make it true, take $c=0$ beyond $r=a_3$; requiring $\mathrm{H}_3=0$ at $r=a_3$. This gives, by (21*b*),

$$\mathrm{A}_3\mathrm{J}_1(n_3a_3)+\mathrm{B}_3\mathrm{K}_1(n_3a_3)=0\quad .\quad .\quad .\quad (26b).$$

Now A_3 and B_3 are, by the previous, known in terms of A_1. Make the substitution, and we find, first, that A_1 is arbitrary, so that it, when given, fixes the size of the whole normal system of electric and magnetic force, and next, that the n's are subject to the following equation,

$$\begin{aligned}&\frac{\dfrac{n_3}{\mu_3}\mathrm{J}_0(n_2a_2)\dfrac{\mathrm{J}_1(n_3a_2)\mathrm{K}_1(n_3a_3)-\mathrm{J}_1(n_3a_3)\mathrm{K}_1(n_3a_2)}{\mathrm{J}_0(n_3a_2)\mathrm{K}_1(n_3a_3)-\mathrm{J}_1(n_3a_3)\mathrm{K}_0(n_3a_2)}-\dfrac{n_2}{\mu_2}\mathrm{J}_1(n_2a_2)}{\dfrac{n_3}{\mu_3}\mathrm{K}_0(n_2a_2)\times\ .\ .\ .\ .\ .\ .\ .\ .\ .\ .-\dfrac{n_2}{\mu_2}\mathrm{K}_1(n_2a_2)}\\ &\quad=\frac{(n_1/\mu_1)\mathrm{J}_1(n_1a_1)\mathrm{J}_0(n_2a_1)-(n_2/\mu_2)\mathrm{J}_1(n_2a_1)\mathrm{J}_0(n_1a_1)}{(n_1/\mu_1)\mathrm{J}_1(n_1a_1)\mathrm{K}_0(n_2a_1)-(n_2/\mu_2)\mathrm{K}_1(n_2a_1)\mathrm{J}_0(n_1a_1)}\quad .\ .\quad (27b)\end{aligned}$$

where, on the left side, to save trouble, the dots represent the same fraction that appears in the numerator immediately over them.

Now, the n's are known in terms of p, hence (27*b*) is the determinantal equation of the p's, determining the rates of subsidence of all the possible normal systems. We have, therefore, all the information required in order to solve the problem of finding how any initially given state of circular magnetic force and longitudinal electric force in the wire, insulator, and sheath subsides when left to itself. We merely require to decompose the initial states into normal systems of the above types, and then multiply each term by its proper time factor ϵ^{pt} to let it subside at its proper rate. To effect the decomposition, make use of the universal conjugate property of the equality of the mutual potential and the mutual kinetic energy of two complete normal systems, $\mathrm{U}_{12}=\mathrm{T}_{12}$ (*Electrician*, Nov. 27, 1885, p. 46), which results from the equation of activity. We start with a given amount of electric energy in the dielectric, and of magnetic energy in the wire, dielectric and sheath, which are finally used up in heating the wire and sheath, according to Joule's law.

It would be useless to write out the expressions, for I have no intention of discussing them in the above general form, especially as regards the influence of c. Knowing from experience in other similar cases that I have examined, that the effect of the dielectric displacement on the wire and sheath phenomena is very minute, we may put $c=0$ at once between the wire and

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the sheath. We might have done this at the beginning ; but it happens that although the results are more complex, yet the reasoning is simpler, by taking c into account.

The question may be asked, how set up a state of purely longitudinal electric force in the tube, sheath, and intermediate dielectric? As regards the wire and sheath, it is simple enough ; a steady impressed force in any part of the circuit will do it (acting equally over a complete section). But it is not so easy as regards the dielectric. It requires the impressed force to be so distributed in the conductors as to support the current on the spot without causing difference of potential. There will then be no dielectric displacement either (unless there be impressed force in the dielectric to cause it). Now, if we remove the impressed force in the conductors, the subsequent electric force will be purely longitudinal in the dielectric as well as in the conductors.

But practically we do not set up currents in this way, but by means of localised impressed forces. Then, although the steady state is one of longitudinal electric force in the wire and sheath, in the dielectric there is normal or outward electric force as well as tangential or longitudinal, and the normal component is, in general, far greater than the tangential. In fact, the electrostatic retardation depends upon the normal displacement. But electrostatic retardation, which is of such immense importance on long lines, is quite insignificant in comparison with electro-magnetic on short lines, and in ordinary laboratory experiments with closed circuits (no condensers allowed) is usually quite insensible. We see, therefore, that when we put $c=0$, and have purely longitudinal electric force, we get the proper solutions suitable for such cases where the influence of electrostatic charge is negligible, irrespective of the distribution of the original impressed force. Our use of the longitudinal displacement in the dielectric, then, was merely to establish a connection in time between the wire and the sheath, and to simplify the conditions. In passing, I may give a little bit of another investigation. Take both electrostatic and electro-magnetic induction into consideration in this wire and sheath problem, treating them as solids in which the current distribution varies with the time. The magnetic force is circular, so is fully specified by its intensity, say H, at distance r from the axis. Its equation is, if z be measured along the axis,

$$\frac{d}{dr}\frac{1}{r}\frac{d}{dr}rH+\frac{d^2H}{dz^2}=4\pi\mu k\dot{H}+\mu c\dot{H},$$

in which discard the last term when the wire or sheath is in question; or retain it and discard the previous when the dielectric is considered. The form of the normal H solution is

$$H=J_1(sr)(A\sin+B\cos)mz.\epsilon^{pt},$$

for the wire, where $s^2=-(4\pi\mu kp+m^2)$. The current has a longitudinal and a radial component, say Γ and γ, given by

$$\Gamma=sJ_0(sr)(A\sin+B\cos)mz.\epsilon^{pt},$$
$$\gamma=-mJ_1(sr)(A\cos-B\sin)mz.\epsilon^{pt}.$$

In the dielectric and sheath the K_0 and K_1 functions have, of course, to be counted with the J_0 and J_1.]

Now put $c=0$ in (27b). We shall have

$J_0(n_2r)=1$; $-n_2J_1(n_2r)=0$; $K_0(n_2r)=\log(n_2r)$; $-n_2rK_1(n_2r)=1$;

which will bring (27b) down to

$$\frac{n_3}{\mu_3}\cdot\frac{J_1(n_3a_2)K_1(n_3a_3)-J_1(n_3a_3)K_1(n_3a_2)}{J_0(n_3a_2)K_1(n_3a_3)-J_1(n_3a_3)K_0(n_3a_2)}$$
$$\times\{(\mu_1a_2/n_1a_1)J_0(n_1a_1)-\mu_2a_2J_1(n_1a_1)\log(a_2/a_1)\}=J_1(n_1a_1),\quad(28b)$$

the determinental equation in the case of ignored dielectric displacement.

To obtain this directly, establish a rigid connection between the magnetic and electric forces at $r=a_1$ and at $r=a_2$, thus. Since there is no current in the insulating space, the magnetic force varies inversely as the distance from the axis of the wire. Therefore, instead of the second of (21b) we shall have

$$H_2=-(n_1/\mu_1k_1p)A_1J_1(n_1a_1)(a_1/r),$$

by the first of (21b). Thus H_2 at $r=a_2$ is known, and, equated to H_3 at $r=a_2$, gives us one equation between A_1, A_3, and B_3.

Next we have

$$\int_{a_1}^{r}(a_1/r)H_1dr=H_1a_1\log(r/a_1)=-(n_1a_1/\mu_1k_1p)J_1(n_1a_1)\log(r/a_1)$$

H_1 meaning, temporarily, the value of H_1 at $r=a_1$. This, when multiplied by μ_2, is the amount of induction through a rectangular portion of a plane through the axis, bounded by straight lines of unit length parallel to the axis at distances a_1 and r from it; or the line integral of the vector potential round the rectangle ; or the excess of the v.p. at distance r over that at distance a_1; so, when multiplied by p, it is the excess of the electric force at a_1 over that at r. Thus the electric force is known in the insulating space in terms of that at the boundary of the wire. Its value at $r=a_2$ equated to E_3 at $r=a_2$ gives us a second equation between A_1, A_3, and B_3. The third is equation (26b) over again, and the union of the three gives us (28b) again.

We now have, if γ_1 and γ_3 are the *actual* current densities at time t in the wire and the sheath respectively,

$$\left.\begin{aligned}\gamma_1&=\Sigma AJ_0(n_1r).\epsilon^{pt}\\ \gamma_2&=\Sigma B\{J_0(n_3r)-J_1(n_3a_3)K_0(n_3r)/K_1(n_3a_3)\}.\epsilon^{pt}\end{aligned}\right\}.\quad(29b),$$

where $$B=A\frac{k_3}{k_1}\frac{J_0(n_1a_1)-n_1a_1(\mu_2/\mu_1)J_1(n_1a_1)\log(a_2/a_1)}{J_0(n_3a_2)-J_1(n_3a_3)K_0(n_3a_2)/K_1(n_3a_3)}$$

in which only the A requires to be found, so that when $t=0$, the initial state may be expressed. The decomposition of the initial state into normal systems may be effected by the conjugate property of the vanishing of the mutual kinetic energy, or of the mutual dissipativity of a pair of normal systems. Thus, in the latter case, writing (29b) thus, $\gamma_1=\Sigma Au$, $\gamma_3=\Sigma Av$, we shall have

$$\int_0^{a_1}u_1u_2rdr/k_1+\int_{a_2}^{a_3}v_1v_2rdr/k_3=0,$$

u_1, v_1, and u_2, v_2 being a pair of normal solutions

We can only get rid of those disagreeable customers, the K_0 and K_1 functions, by taking the sheath so thin that it can be regarded as a linear conductor—*i.e.*, neglect variations of current density in it, and consider instead the integral current. (Except when the sheath and wire are in contact and of the same material, as in the last section.) Let a_4 be the very small thickness of the sheath, and evaluate (28b) on the supposition that a_4 is infinitely small, so that a_2 and a_3 are equal ultimately. The result is

$$J_0(n_1a_1)=a_1J_1(n_1a_1)\{(n_1\mu_2/\mu_1)\log(a_2/a_1)-k_1/n_1k_3a_2a_4\},\quad(30b)$$

the determinantal equation in the case of a round wire of radius a_1 with a return conductor in the form of a very thin concentric sheath, radius a_2. Notice that μ_3, the inductivity of the sheath itself, has gone out altogether ; that is, an iron sheath for the return, if it be thin enough, does not alter the retardation as compared with a copper sheath, provided the difference of conductivity be allowed for.

We may get (30b) directly, easily enough, by considering that the total sheath current must be the negative of the total wire current, which last is, by integrating the first of (29b) throughout the wire,

$$=(A/n_12\pi a_1\Sigma)J_1(n_1a_1).\epsilon^{pt}.$$

This, divided by the volume of the sheath per unit length, that is, by $2\pi a_2a_4$, gives us the sheath current density, and this, again, divided by k_3 gives us the electric force at $r=a_2$. Another expression for the electric force at the sheath is given by the previous method (the rectangle business). Equate them, and (30b) results.

We have now got the heavy work over, and some results of special cases will follow, in which we shall be materially assisted by the analogy of the eddy currents in long cores inserted in long solenoidal coils.

(To be continued.)

FORTHCOMING SALE OF SURPLUS PLANT.—On reference to our advertisement columns it will be seen that the sale by Messrs. Wheatley Kirk, Price, and Goulty of the Edison and Swan United Company's stock of surplus electrical plant has been postponed from June 23rd and 24th to Wednesday and Thursday, July 7th and 8th.

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PRACTICAL ELECTRICITY FOR AMATEURS.—III.*

Electric Bells and Indicators.

At the latter part of our last article, Fig. 16 was without the reference letters referred to in the description; *a* is the upper contact against which the button spring is pressing, the *b* after the word bell is not required, *c* is the bottom contact against which the button spring comes when the button is pressed.

Indicators.—Where electric bells are fitted to several rooms it is necessary to use indicators, several being placed in one case. Fig. 17 shows a design much used on the Continent. It consists of a fixed electro-magnet, M, and permanent magnet, N S, to which is attached a pivoted arm, carrying a light, parti-coloured vane at the top. The connections are so made that when a push is acted upon, M attracts N and repels S, causing the vane to take the position shown, to reset the vane, a button placed in or near the indicator case is pressed, which sends a current in the reverse direction, causing M to repel N and attract S, thus throwing the vane over into its normal position.

In this country indicators which drop a shutter or disc are mostly used, but the pendulum indicators which swing for a considerable time and do not require resetting are much to be preferred. One form of this kind is shown by Fig. 18. The vane is preferably made of corrugated silvered glass, which can be seen in dark situations, where a coloured vane would be quite undistinguishable.

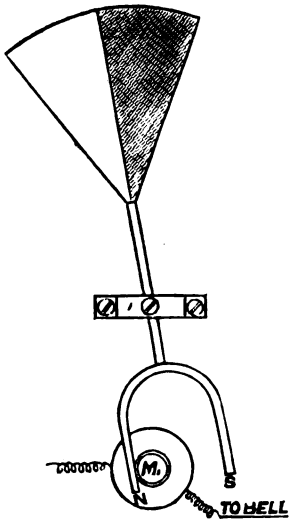

Fig. 17.

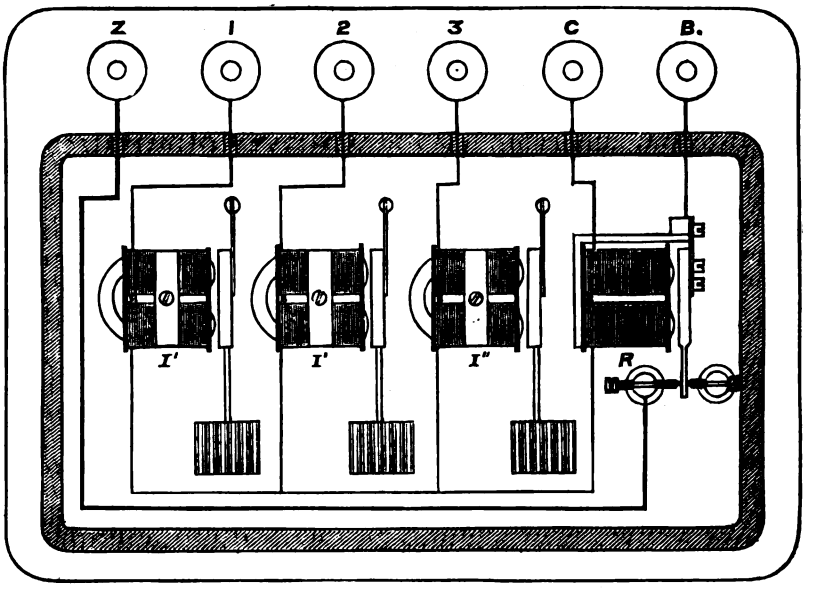

Fig. 19.

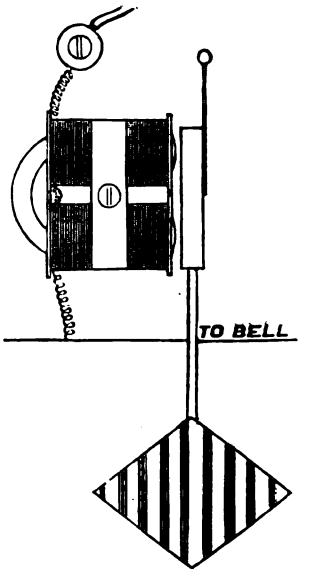

Fig. 18.

The grouping of the indicators in one case is shown by Fig. 19; the current enters by terminals 1, 2, or 3, as the case may be, traverses the coils of the particular electro-magnet connected therewith, reaching the coils of relay R by the wire common to all (causing the local bell circuits to be closed, thus ringing the bell), then to C, which is connected to carbon of battery.

The Battery.—The best battery for general electric bell work is undoubtedly the Leclanché, and preferably the *old form* of that kind; in very large hotels, however, the Fuller bichromate battery may be preferable.

Fire Alarms and Thief Detectors.

Fig. 20 shows a good form of door or window contact. The bolt is held back against the pressure of the spring, so that the circuit is broken, but when the door or window is opened the bolt comes forward into contact with the block, thus completing the circuit, and causing the bell to ring. These should be placed in door posts on the hinge side, and in window frames at top and bottom.

Fig. 21 shows a fire or frost alarm. It consists of a metal tongue of brass and steel, riveted together and fixed at one end, the other end being free to move between the stops A and B,

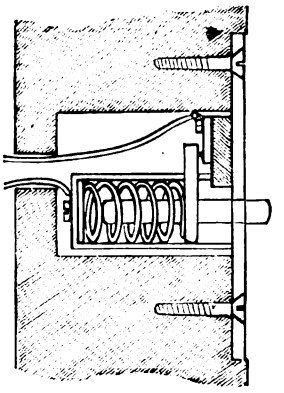

Fig. 20.

the action of heat moving the tongue towards the stop A, and the action of cold towards the stop B. This arrangement is very useful in greenhouses, &c., giving immediate notice of too great heat or cold by ringing a bell, or it can be made to act upon the ventilating and heating arrangements direct.

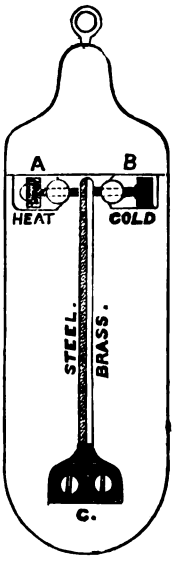

Fig. 21.

* For Article II. see *The Electrician* for May 21, 1886.

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For purely fire alarm purposes, a modification of a differential thermometer is perhaps the best, as the alarm is only given when a sudden rise of temperature takes place, and not when a predetermined temperature is attained.

CONNECTING-UP BELLS, INDICATORS, AND BATTERIES.

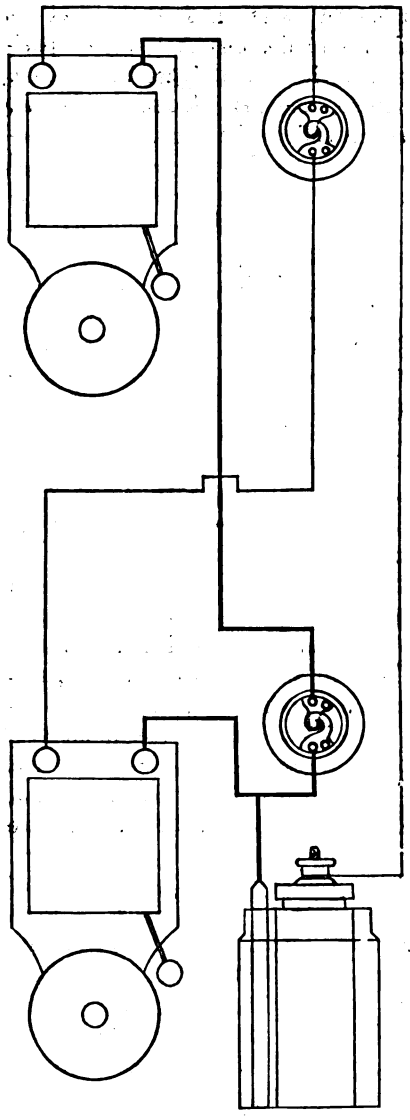

FIG. 23.

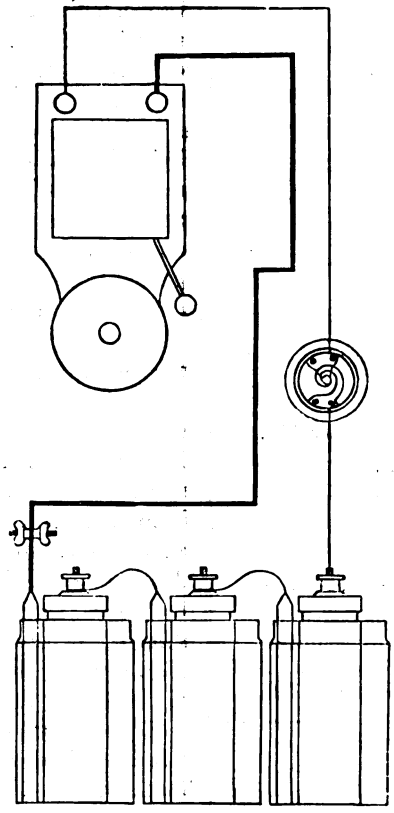

FIG. 22.

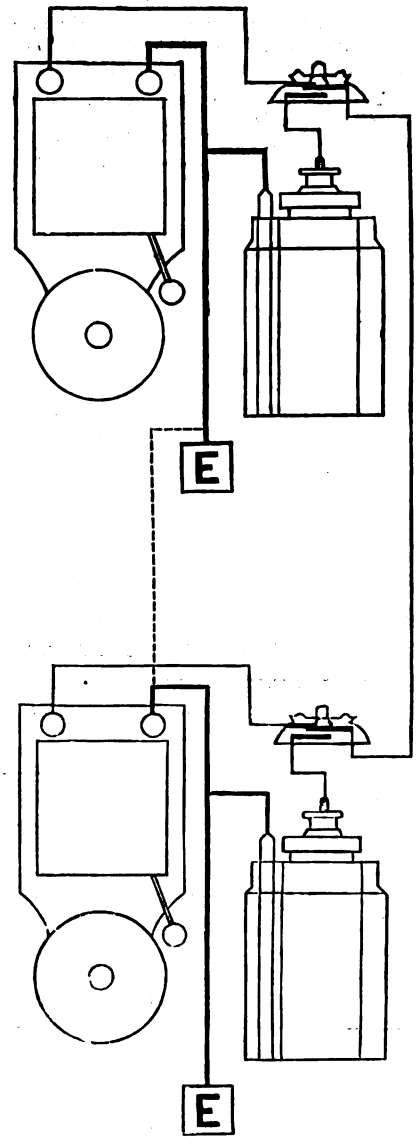

FIG. 24.

It is hoped the following diagrams are sufficiently distinct, so that very little description will be required. The Z or return wire is shown thicker than the C wire. Fig. 22 shows a simple bell circuit.

Fig. 23 shows an arrangement of electric bells to ring in both directions, using only one battery and ordinary pushes, but requires *three* wires, and is therefore only suitable for short distances.

Fig. 24 shows another arrangement to ring both ways, requiring "key pushes," previously described (Fig. 16, page 27), a battery at each end, one line wire, and earth connections (a water-pipe is sufficient), or a second line wire (as shown by the dotted line) may be used.

Fig. 25 shows method of connecting up continuous ringing bell, shown by Fig. 6, page 26.

Fig. 26 shows connections for continuous bell, shown by Fig. 7, page 26.

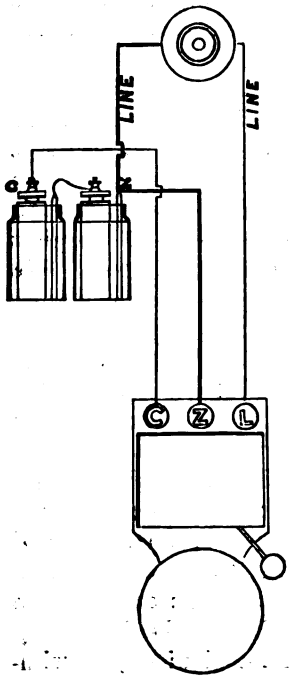

FIG. 25.

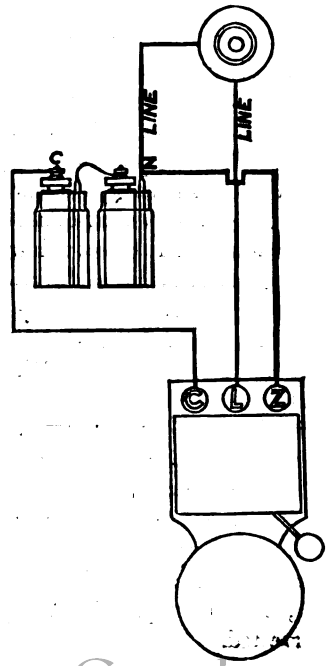

FIG. 26.

FIRING SHOTS IN MINES.—MM. Scola and Ruggieri have suggested a modification of the usual method of firing shots in mines. The ends of two cotton-covered copper wires are wound upon a small wooden cylinder. Around the wires is a cartridge filled with a mixture of chloride of potash, saltpetre, sulphide of antimony, and finely divided carbon; the latter is used to give feeble conductivity to the mass. The wires are connected with an induction coil, and a spark obtained at will to explode the mixture and powder or dynamite of the charge.

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THE ELECTRIC LIGHTING ACT AMENDMENT BILL.

It will be seen by an announcement we make in another column that of the three measures for amending the ELECTRIC LIGHTING ACT of 1882, referred to a Select Committee of the House of Lords a few weeks ago, the one submitted by Lord HOUGHTON on the part of the Government has been adopted. It does not follow that this Bill as finally agreed upon by the Committee will become law, or that it is still incapable of being amended in a direction more favourable to Electric Lighting undertakers. Parliamentary committees of inquiry usually contain a preponderance of Government supporters; and as the present Ministry are pledged to resist the creation of any fresh vested interests, except under conditions which secure a reversionary interest to the local authorities, it is not surprising that the scheme of amendment put forward by Lord HOUGHTON has secured a majority of votes. The Bill, which we print in another column, shows, however, that its competitors have exerted some salutary influence on its provisions; and that, in fact, it is a compromise designed to reconcile all the parties interested.

There is undoubtedly much reason to be gratified with the general drift of these proceedings, even though we may not be entirely satisfied with the present result. In the first place it was a great triumph for the opponents of the Act of 1882 to have extorted an admission from a Government which enacted the abortive measure, that not only had it failed to do what it professed to do, but that it had positively undone all the work that it was designed to promote. A fresh start had to be made, and Lord HOUGHTON'S Bill, introduced on the 1st April, extended the term of the provisional order to 30 years, and, with the consent of the local authority, to a further term of 12 years. The principle of compulsory purchase, or confiscation as it may be more correctly designated, was maintained, but its period of grace was enlarged by at least one-third. A principle so elastic as this is obviously capable of expansion; a further concession of 20 or 30 years would be quite consistent with its essence; and except for the fact that the dominant political party just now is hostile to the leasehold system, a 99 years' lease might be granted to the undertakers without in the least violating the principle of compulsory reversion.

It will be remembered that the two Amendment Bills introduced respectively by Lord RAYLEIGH and Lord BURY were framed on different lines. Lord RAYLEIGH proposed to abolish Clause 27 absolutely, and to place Electric Lighting enterprise on identical, or almost identical, footing with Gas Lighting and other similar commercial undertakings. Viscount BURY, yielding more to the spirit of the age, was content to extend the operation of the provisional order from 21 to at least 42 years; but with this important difference, that instead of authorising a purchase on the basis of "old material," he insisted that the business should be valued and paid for as a "going concern." Lord HOUGHTON'S alternative on the part of the Government extended the minimum term to 30 years, but did not modify in any way the conditions of purchase laid down in the Act of 1882. He objected to Lord RAYLEIGH'S Bill because it would establish a new set of vested interests; which was quite true, though we do not see the force of the objection. And he objected still more to Lord BURY'S proposal because "it would create a more dangerous because more insidious form of monopoly;" which is by no means obvious, and even if it were, the Government proposal is open to a similar objection, unless, indeed, the difference between a dangerous monopoly and an innocent monopoly is that the one may not be deprived of its rights without compensation, whilst the other may.

It is absurd to use language like that ascribed to Lord HOUGHTON in reference to a purely business matter, one essential element of which is common honesty. Without that as a preliminary security there can be no business, as the Act of 1882 has sufficiently demonstrated. The real danger lies in creating uncertainty of tenure and certainty of risk, against which no healthy or legitimate business can contend. We should suspect the good faith of any undertaking which accepted the terms of Lord HOUGHTON'S original amendment Bill; and apparently he has been brought to see this himself. In the Bill as amended after the ordeal of a Select Committee, we find that he has consented to a further extension of the term of the provisional order to 42 years, the period demanded by Lord BURY, and has so far yielded in respect to the conditions of sale that they are subject to variation at the hands of the Board of Trade. If we understand rightly Section 2 of the amended Bill, the parties seeking a provisional order may make their own arrangements with the Board of Trade as to the terms upon which the local authority may require the undertakers to sell their business, notwith-

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standing anything to the contrary in Section 27 of the original Act.

If we are right in this interpretation the most objectionable feature in the Act of 1882 will have disappeared; and it will rest with the applicants to make the best bargain they can with the Board of Trade in each separate case. It is an ungracious way of conceding an equitable principle, but it is better than leaving the opposite principle rigidly fixed by Act of Parliament. On the whole, therefore, there is much reason for congratulation at the progress made in this prolonged struggle. The Bill, under existing circumstances, is hardly likely to pass in the present Session; but this is, perhaps, not wholly to be regretted. Delay will afford time for carefully weighing the advantages and disadvantages of working under the provisions of the Act. Every year of untrammelled enterprise has proved of service to electric lighting undertakers, and has rendered them less and less eager to enter prematurely into speculations of great magnitude except on terms that are attractive and safe. Nothing less than an extension of the provisional order to twice its original duration will now be accepted, and a test application to the Board of Trade will, whenever the Bill passes, quickly reveal the conditions of purchase which that body is disposed to entertain.

CORRESPONDENCE.

CURRENT INDUCTION.

TO THE EDITOR OF THE ELECTRICIAN.

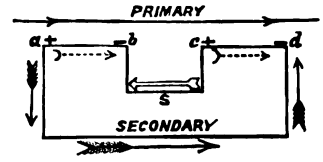
SIR: I ask your leave to reopen a correspondence under the above heading, which the force of circumstances compelled me to leave on one side last December. I am concerned in this matter partly with Mr. Sprague and others about the behaviour of induction coils, and partly with your American reader, Prof. T. A. Smith, on a far wider issue about the nature of current induction in general. It is the latter thread which I now propose to take up.

As regards the process of induction, it was my contention that there was in the portion of the secondary wire under influence a temporary slope of potential, caused by the outsetting primary current, this slope being downwards in the direction of the primary current; and I described this transient slope to a modification of the capacity along the secondary wire similar to that which takes place in the insulated cylinder familiar to us all in connection with electrostatic induction. I was led to surmise that possibly the phenomena of current and electro-magnetic induction could be traced to the first principles of electrostatic induction. If, however, Prof. Smith's experiments were made (as I presume to be the case) without an iron core, and were such as to show the unadulterated influence of current on neighbouring wire, then I am compelled to acknowledge at once (as I was all but compelled to do beforehand) that the inductive action of the primary is the working of what I may call its *magnetic faculties*, and is in no way due immediately to the *decline of potential* throughout its course.

Meanwhile, my thanks to Prof. Smith for guiding me; and, indeed, guide me is just what he has done, for his useful experiments by no means subvert those elements in my theory to which I cling so tenaciously, and for which I have claimed the support of "cogent arguments." As a step towards explaining this selection among my heretical tenets, may I say that this new theory is not a mere fancy of the imagination, without relation to known facts? The facts upon which I have built it are the great and leading facts of current induction investigated by Faraday. I have been reproached with having no facts in support of my theory. True, I have not any newly discovered phenomena to present to the world; but I offer new reasonings on old, prolific facts, never yet exhaustively dwelt upon. In the present mathematical age of science, purely physical questions such as that of the condition of a secondary wire in the "electrotonic" state are a little apt to be neglected. Faraday did not get so far as to define in what this state consisted; but at least he recognised it and christened it with a name. Meanwhile the efforts he made in this direction have been suffered to lapse into oblivion.

Now the essence of the view I have been proposing about current induction lies in this, that a secondary wire whilst under influence is in a condition similar to that of the insulated cylinder of electrostatic induction with a charged ball held near to one extremity. In the case of the cylinder the presence of the + charged ball near one end causes the electric capacity to diminish at that end and to increase at the other end, viz, that towards the wall or other object representing the earth which holds the fellow charge of −E. Now, a diminished capacity involves a rise of potential, which is adjusted only by a proportionate diminution of charge at the near end of the cylinder; hence a transfer of the "electric fluid" to the further end—all which is orthodox enough. I conceive a similar process to take place when a neighbouring wire is influenced by the outsetting primary current; but I must now avoid the error into which I was previously decoyed of supposing that the similar action is due to a similar agent (such an agent being actually present); for I now attribute the action, not to any difference of potential at each end of the inducing wire, but to the magnetic faculties of the primary current.

It was a salient feature in my heterodox view, that I assigned a reverse direction to the secondary current through the part in which the E.M.F. is generated, or, as I originally expressed it, through the portion "under influence." Such a theory is indicated by the dotted arrows in the diagram, whilst the plain



arrows show the currents familiar to all, and the broad arrow a particular result obtained by Prof. Smith, who tested the direction of the current in an internal loop *b s c*. Now, it will be seen at a glance that there is nothing irreconcilable in the relation between the broad arrow and the dotted arrows. Prof. Smith directed his experiments against the view that there was a gradual decline of potential along *ab . . . cd*, and he proved that *b* was not + to *c*, but the reverse. But on the issue, What is the direction of the current in a portion under influence? we are still awaiting evidence, for the loop tested by Prof. Smith was *not* under influence but distinctly removed from the influence of the primary current. For my part I scarcely see how to determine this question by any direct experiment, unless perhaps an electro-chemical test could be contrived. But in the meantime let us remember that the question is an open one; and on my own side of the matter arguments of an indirect kind will not be wanting.—Yours, &c.,

E. ALDRED WILLIAMS.

37, Burlington-road, W.

ELECTRIC BELLS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the first letter in your issue of last week signed by "The Writer of the Articles," your correspondent seems to hint that I wish to depreciate the value of his writings. I regret that he should think so, and can only say that I fully appreciate the value of his articles, and my communication was simply intended to make them (if possible) more complete by describing the latest improvements and designs that are upon the market and not noticed by him.—Yours, &c,

C. B. CALLOW.

11, Clerkenwell-green, London, E.C., June 9, 1886.

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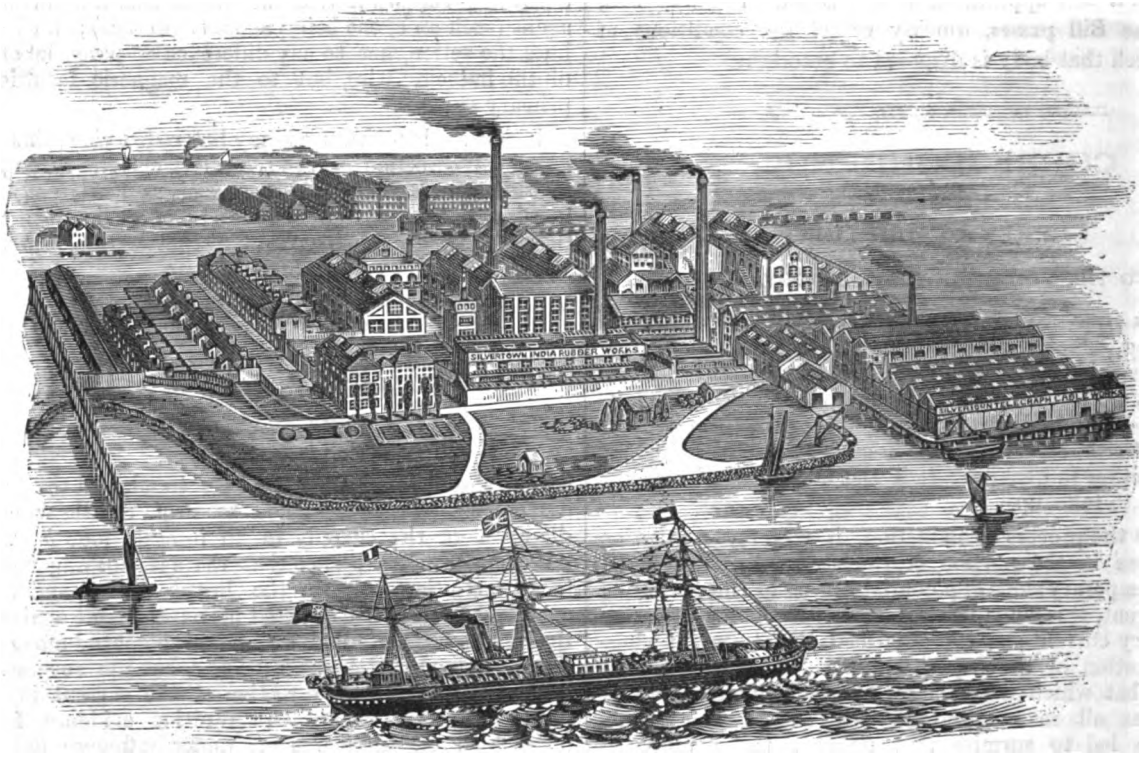
VISIT TO SILVERTOWN.

On Thursday, the 10th inst., the directors of the India Rubber, Gutta Percha, and Telegraph Works Company invited the representatives of the Colonial and Indian Exhibition to visit their extensive works at Silvertown, of the magnitude of which our illustration will give some idea. The greater portion of the guests assembled at the Temple Pier and made the journey by a boat specially provided by the company. On the arrival at the works some eight or ten smaller parties were formed from the assembled guests, and, conducted by gentlemen well acquainted with the works, were thus able to have explained to them in detail the various processes they were examining. The visitors were first led into the gutta percha department, where specimens of the crude material were seen, and the different processes of purifying and treating gutta percha were shown.

Gutta percha is principally obtained from the Malay Peninsula and the islands of the East Indian Archipelago, and is the gum of the tree *Isonandra gutta*. It was first brought to England in the year 1843. It is collected as it oozes from incisions in the tree, and is afterwards dried. When it arrives in this country it frequently contains as much as 25 or 30 per cent. of impurities, and is brought in lumps of a brown colour, having somewhat the appearance of leather, and with a peculiar odour.



The Silvertown Works of the India Rubber, Gutta Percha, and Telegraph Works Company (Limited).

In the cleaning and masticating workshop the raw material as it arrives in England was seen. The boilers, the cleaners, and the masticators were shown in operation, where the natural juice of the gutta percha is removed and the material made homogeneous. Hydraulic presses are used to force the gum in a plastic state through exceedingly fine wire gauze, in order to remove the sand and bark. When the gutta percha is strained it is rolled and stored until required for the various manufactures in which it is used.

The visitors then went to the upper floor of the wire-covering department, where the copper wire conductor was being formed. On the lower floor this conductor was seen receiving its covering of gutta percha. The core of a submarine cable is formed by drawing it through a specially-constructed die containing plastic gutta percha under pressure, whence it issues coated to the required thickness; it is then hardened in cold water, and coiled on bobbins, to be afterwards inspected in order to discover any imperfections. This core—or insulated conductor—is coiled on large bobbins in two-mile lengths, and placed in a cistern containing water at a heat of 75 degrees Fahrenheit. The ends of the core are taken into the testing room for the purpose of ascertaining if the work of covering the copper with gutta percha has been successfully done and the insulation perfect.

On leaving the testing rooms the visitors were conducted to the submarine cable workshops to inspect the sheathing of the cable being manufactured to connect the West Coast of Africa with Europe. In the lower cable shop the machines were at work sheathing the shore ends and intermediate types of cable, weighing respectively sixteen tons and five tons per nautical mile. In the upper shop the deep-sea cable was seen in the process of covering the core with yarn, iron sheathing wire, and a bituminous compound to protect the iron wire from oxidation and from the *teredo navalis* and other marine insects.

On leaving the cable workshops many of the visitors went on board the telegraph ship "Silvertown" to see the cable shipped and put into the tanks, and to inspect the machinery employed in laying telegraph cables. This ship is in a few days going to the West Coast of Africa with about 2,000 miles of cable. The total cargo, including coals and stores, will weigh more than 7,000 tons. A visit was then made to the India Rubber Department, to see the treatment of india rubber in its application to various purposes. India rubber is chiefly received from the Brazils (Para, Ceara, &c.), and from Guayaquil, British India, and Madagascar. It is collected from the *Jatropha elastica*, in a similar manner to gutta percha, but with the exception of Para rubber, the impurities are greater. The first process of manufacture is to get rid of these impurities by cutting the gum into pieces and thoroughly washing and amalgamating it; after which it is dried and mixed with the materials necessary for its different purposes. It is usually mixed with sulphur, then moulded into the required forms, and exposed to a heat of about 300 deg. Fahrenheit, which causes a chemical action, completely changing the nature of the material, and fixing it in the shape designed. When the quantity of sulphur and the period of exposure to heat are increased, and the rubber is exposed to heat, ebonite or vulcanite is produced.

After inspection of this department the visitors were entertained at luncheon, Mr. Silver, the chairman of the Company, presiding. Various toasts were enthusiastically drunk, especially that of "Our Visitors," which was responded to by the representative of Tasmania.

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Just before luncheon a torpedo was exploded, some of the visitors stating that Colonel Bolton must look to his laurels, for the fountains of South Kensington were nowhere beside the display occasioned. After luncheon the torpedo and electric light departments were visited, and thus concluded the inspection of the works, the guests returning by a special train from Silvertown Station to Liverpool-street.

We have only been able to describe thus briefly a most interesting visit to one of the largest works engaged in the construction of telegraphic apparatus of all kinds in the kingdom; but we are quite sure that the guests will carry away with them a vivid recollection of the immense progress that has been made in the manufacture of apparatus connected with all branches of electricity during recent years.

RESEARCHES UPON THE SELF-INDUCTION OF AN ELECTRIC CURRENT.*

BY PROF. D. E. HUGHES, F.R.S.

(Continued from page 73.)

Reactions of an Electric Current between Separate Portions of the same Conductor.

In order to distinguish two distinct effects I have defined self-induction as the effect produced by an electric current on its own portion of the wire, and mutual induction as the effect of the reactions between separate portions of the wire on each other.

The mutual induction in iron and copper wires is very different in degree, as shown by the following table:—

TABLE I.

Wires, silk-covered 1 m. in length, 1 mm. in diameter.	Comparative force of the extra currents.	Strips or ribbons, silk covered, 1 m. in length, 10 cm. wide, 0·1 mm. thick.	Comparative force of the extra currents.
Copper wire, in a single close loop, where each side is in close proximity ...	18	Copper strip, in a single close loop, where each side is in close proximity.	14
Copper wire, in a single wide circular loop	100	Copper strip, in a single wide circular loop.....	60
Copper wire, in a coil of 3 cm. diam., having ten layers in close proximity	607	Copper strip, in a coil of 3 cm. diam., having ten layers in close proximity ...	580
Iron wire (soft), in a single close loop, as above	440	Iron strip (soft), in a single close loop, as above	16
Iron wire, in a single circular wide loop	502	Iron strip, in a single circular wide loop..	60
Iron wire, in a coil as in the case of copper	570	Iron strip, in a coil as stated for copper...	578

There is a remarkable fall in the induction of a straight wire or single wide loop of a copper wire when this wire is doubled upon itself as a return wire in close proximity. The effect of mutual induction is also shown by the equally remarkable rise when the mutual induction of ten layers of a coil react on each other. This is well known, but what I believe has not yet been experimentally observed is the remarkably feeble mutual induction of iron wires, either when in parallel return in close proximity or when in coils of numerous layers, the percentage of increase of induction in a copper wire from a wide single loop to that of the ten layers being 507 per cent., whilst in iron under precisely the same conditions there was an increase of but 13·6 per cent.

That this remarkable difference as shown between the mutual induction of iron and copper wires is due entirely to the circular magnetism in the iron wire, and that the mutual reactions of the streamlets of the current in a thin flat iron conductor prevent this formation, I have proved in various ways; for if the circular magnetism is the cause, flat iron sheets which have as low self-induction as copper should be equally sensitive to mutual induction as the non-magnetic metals, for they no longer in any appreciable degree possess the protecting magnetic sheath which enfeebles the mutual reactions of iron wires upon each other; this proves to be the case, a thin ribbon of iron having the same coefficient of mutual induction as copper, and it no longer behaves as a magnetic body.

* Read at the Royal Society, May 27, 1886.

Table I. shows the difference in the mutual induction of iron wires and strips; it will be seen that when the iron is in the form of a wire the circular magnetism produces a marked difference between iron and copper, whilst in the form of flat strips the iron resembles copper (as regards mutual induction) in every respect.

Influence of Circular Magnetism.

I have shown in my late paper that an iron conductor composed of numerous fine stranded wires (as in a rope) behaves like copper, and this I regard as entirely due to the breaking up or prevention of circular magnetism; I also showed a phenomenon which I could not then explain, viz., that when an iron wire was heated to a yellow-red heat it lost its previous high specific inductive capacity and behaved like copper. The effect of heat upon magnetism is well known, consequently we can readily explain the fall in its inductive capacity by the disappearance of its circular magnetism. I found also that in thin flat strips of iron there was no change whatever in its inductive capacity at the yellow-red heat. This can now be readily explained; it behaved like copper when cold, and, having but little circular magnetism to destroy, there was no appreciable change produced, except that due to the extra resistance caused by the increased temperature of the strip, and to which copper and iron are almost equally sensitive; consequently we may consider iron (when in the form of thin flat sheets) to behave like non-magnetic metals throughout all temperatures.

Influence of Self-Induction on the Resistance of the Conductor.

A phenomenon of great importance is the effect which I have observed of the resistance of a wire being greater during the rise of the current, as in the variable period, than that measured or known during the constant flow, as in the stable period. By resistance I mean a pure ohmic resistance, a resistance which can only be measured, expressed, or balanced in ohms, and, whatever the cause, the effect is one of pure ohmic resistance.

We can imagine that at the first moment of contact there is no current flowing through the wire; its resistance is then infinite, but the current gradually increases in force until it arrives at its maximum, as in the stable period. We have thus between the moment of contact and period of steady flow a variable period wherein the resistance falls in the form of a curve from infinity to its well-known stable resistance; the telephone is unable to give the exact form of this curve directly, but it gives by the nul method comparative results as to the different duration in time of the curve in different metals.

If we take a straight copper wire 1 metre in length and balance its resistance in the stable period, we shall find only traces of a difference in its resistance in the variable period, and we can balance its self-induction by the induction balance; but if we replace the copper by an iron wire of the same length, or even a much shorter wire, viz., 20 cm., we find that in the variable period we can no longer balance the wire by the induction balance alone, but we must compensate for its increased resistance by the sliding scale, the amount of subtracted German silver wire expressing in fractions of ohms (the value of the wire being already known) the additional resistance of the iron wire in the variable period; we can thus reduce or balance the iron wire to a perfect zero, provided the current from the battery does not exceed 0·10 ampere; but with greater current there will still remain a slight muffled sound, which cannot be reduced to zero either by the induction balance or the resistance slide. It therefore became important to determine if this muffled sound was due to a difference in resistance which could not be balanced, or to the lengthened duration of the extra currents being slower than the balancing current from the induction balance; the latter proved to be the case, for on prolonging the duration of the balancing currents from the induction bridge by introducing a core of iron in its coil, the balance or zero became absolutely perfect. In this case we must choose between cores of different diameter to find one whose reaction on the time effect of the induction coil equals the retardation of the extra currents in the wire tested.

If we observe the method employed in the bridge, we shall see that the induction balance can balance the extra current of the wire X, irrespective of the position of the resistance slide M, or any relation between the sides A B and A D. But we cannot equalise the resistance of these sides except by the necessary adjustment of the resistance slide; consequently when we are forced to adjust the induction balance we are compensating the extra current, and when we are forced to move the resistance slide we are balancing resistance.

The disturbance in the bridge caused by the change of resistance of the wire tested in the variable period, causes a momentary primary current to pass through the telephone in the same direction as the extra current, and if these are not separated by balancing the extra current by an induction balance, the mixed effect would be read as a single effect of the extra current. To show the importance of separating these two effects, it is only necessary to

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say that in most of the cases cited in this paper the momentary primary current due to the extra resistance greatly exceeds that of the extra current; consequently all measurements taken wherein this separation is not complete give the result of a mixed effect.

In the method which I have described, the separation of the extra current from the momentary primary current is so complete that the measures given by the induction balance and resistance slide are invariably the same for a given wire; there is no personal equation, for all observers find precisely the same values both for the resistance and for the extra current.

The method is, however, defective in measuring any small difference of resistance in the variable period in copper wires, as the induction balance itself introduces an additional but opposing resistance by the approaching of its coils, consequently any resistance which we observe is a fraction less than the real amount. To prove this we have only to use a balancing induction current produced from the battery circuit, as shown in my first paper, when we observe this small difference, and, better, observe any small difference of resistance in a straight copper wire, and greater when the wire is formed into a coil.

Soft iron wire gives a far higher resistance in the variable period than hard iron, but each wire, according to its molecular structure, has its own value; the effect increases with the diameter, ranging from 25 per cent. increase of resistance for wires of 2 mm. in diameter, to 500 per cent. for those of 6 cm.

TABLE II.—Resistance of Iron and Copper in the Stable and Variable Periods.

Wires, 1 m. in length, 5 mm. in diameter.	Comparative force of the extra current.	Resistance in ohms, stable period.	Resistance in ohms, variable period.	Percentage of increased resistance in variable period.
Copper	78	0 001284	0 001372	7
Soft Swedish iron...	234	0·008346	0·022200	166
Americ'n compound wire, copper exterior, steel interior	83	0·002247	0·002696	20
Ditto, steel exterior, copper interior...	213	0 007750	0·0248000	220

Table II. shows a few illustrative examples. The resistance is given in the fractions of the ohm, indicated by the resistance slide M, upon the supplementary resistance wire H 1.

The table shows that copper and the American compound wire coated with copper have an extremely rapid action or curve from an infinite to its stable resistance, due to their freedom from circular magnetism, whilst iron shows a comparatively slow curve.

A remarkable result will be seen where a copper wire has been coated with iron, its variable resistance being 220 per cent. above that of its stable period, and 54 per cent. greater than that of a solid iron wire.

I found in my previous researches that the resistance in the variable period could not be changed by a change in speed of a periodic or tuning fork contact maker, and that the telephone was more sensitive when the rubbing contacts were used without any regard to their frequency of interval. I also found that the telephone was far more sensitive and alone suitable for these experiments when its diaphragm was entirely free from varnish or coating, and sufficiently thick to give a clear musical dominant tone of about C or 512 double vibrations per second, the electromagnet being also as close as possible without being in actual contact. I noticed that, no matter what number of vibrations were sent, the tones given by the telephone on each side of the zero of the bridge were invariably those of its dominant note. Suspecting that the frequency of vibration of the diaphragm had a direct relation with the resistance found, I altered its note through a range of one octave by employing different thicknesses of diaphragms, and found that the results were in absolute proportion to the frequency of the vibrations of the diaphragm, the highest tone giving a perfect zero with a high resistance in the variable period, and the low tone giving its zero at a marked less resistance. Thus it was evident that the telephone selected from the mixed vibrations sent by the transmitter those which alone corresponded to its period of vibration, and that we could thus observe the effect of more or less rapid periodic contacts.

The power which vibrating bodies have of selecting from a confused number of vibrations those in accordance with their own is shown in Helmholtz's resonators, and still more as regards electrical waves in the remarkable harmonic telegraph of Elisha Gray, who proved that if the armatures of several electromagnets are made to vibrate, each with a different musical tone or rate of vibration, then we may by the use of a vibrating transmitter of a fixed rate of speed select the electromagnet alone whose period of vibrations is similar, and that we may send several different periods of vibrations at the same time without any confusion in the receiving magnets, as each electromagnet selects from the compound vibrations those in accordance with its own. This is exactly what occurs with a telephone when using a periodic contact maker, but I have found in addition that a telephone arranged as I have described, will select and respond loudly in its own clear musical dominant tone to a confused mass of rapid contacts such as those produced by a scraping contact, and which in an ordinary telephone gives only the effect of noise of not one-third the power or loudness of that produced by the tone of the musical telephone. We may thus have ten or more telephones of different musical notes, each responding separately in their own tone or all at the same time, as each diaphgram selects its own period from the confused periods of contacts sent by the scraping contact maker.

In order to verify the results, I have used in these experiments both periodic and mixed sound transmitters, but find that owing to the difficulty of keeping the periodic transmitter and telephone in perfect tune with each other, that the mixed sound transmitter is preferable, as it gives no trouble whatever, and we have more accurate results, as we then have only to keep our telephones in accord with the number of vibrations desired.

The experiments mentioned in this paper were all made with a fixed note of vibration of the diaphragm of 512 double vibrations per second. I will, however, mention a few made with varying rates of vibration, and as I propose in a future paper to give a more extended series of observations through a wider range, I will confine myself to these examples.

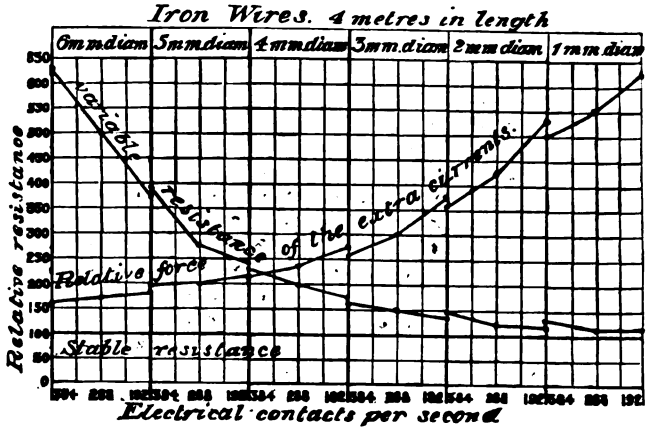

FIG. 2.

The diagram shows the results obtained on iron wires of different diameters; their stable and variable resistance were all reduced to comparative values, the stable resistance being taken as 100. Three telephones were employed, the first having the musical note of G or 768 double vibrations, the second C sharp or 576 double vibrations, and the third one octave below the first or G 384 double vibrations per second.

It will be seen that a great change in the variable resistance takes place in the range of a simple octave, and that the fall from the wires of 6 mm. to that of 1 mm. is so regular as to be almost a continuous curve, and the total curve would be probably that taken by the wire of 6 mm. in its approach to its stable resistance.

If this is the case, as future researches may show, then the resistance of this wire with the comparatively slow contact speed of six per second would still have 14 per cent. higher resistance in the variable than in the stable period, or an ordinary Morse telegraph instrument working at a slow speed of only eleven words per minute would experience this additional resistance; consequently, this effect should be easy to prove by the ordinary methods with galvanometers, and this can be accomplished as soon as we have found a method of completely separating the extra current from that due to the increased resistance, as I have already succeeded in doing by the method which I have described.

The iron wire of 6 mm. diameter shows for a speed of 384 contacts per second a comparative resistance in the variable period of 638, or more than six times its stable resistance, but with 192 contacts per second its resistance is but 371; the fall of resistance is so rapid here that for a single octave difference in the telephones, the fall is far greater than the whole stable resistance. The extra current, as well known, is proportional to the length of contact for fine wires, but in large wires the curve indicates that the extra currents have a local reaction on the cessation of the primary current.

(To be continued.)

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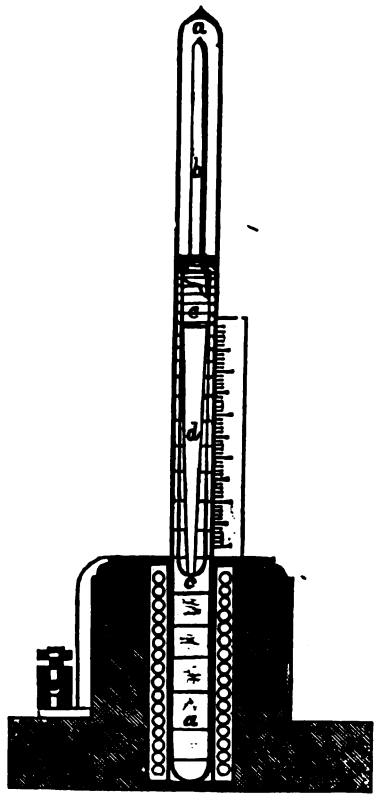
CONTRIVANCES OF THE NATURE OF AEROMETERS FOR MEASUREMENT OF CURRENTS & POTENTIALS.

The idea of balancing the attraction which a solenoid exerts on a piece of soft iron against the resistance which a fluid exerts to the lowering of a floating body has been repeatedly employed to measure currents and potentials. Karl Raab has had different arrangements of this fundamental idea patented. The figure shows one of these arrangements. In the hollow of a solenoid there is fastened a glass tube, closed at both ends, which is filled with alcohol or some other mobile liquid. On the liquid floats the glass aerometer *b c*, which contains in its under part a thin conical iron tube, *d*. When a current passes through the solenoid the attraction of the iron core causes the aerometer to sink more or less according to the strength of the current. The scale is divided empirically. The magnetic force keeps the aerometer always in the centre of the glass tube, so that it does not adhere to the sides. The wording of the patent would include a somewhat similar contrivance designed by Lalande.



It is believed that this kind of instrument may be very useful with a fitting choice of the form and quality of the iron core ; but the heating of the coil by the passage of the current may make corrections necessary on account of the alteration of the density of the fluid and of the volume of the different parts of the instrument, and it will be necessary for great accuracy to place a thermometer in it. To make the heating of the coil have as little effect as possible, it would be advisable to separate it by a layer of air from the glass tube.—*Elektrotechnishe Zeitschrift.*

PROF. FORBES' CANTOR LECTURES.

LECTURE IV.

(Continued from page 78.)

In the previous lecture we saw the means by which we could create electric currents, and we saw something of the way in which those electric currents act. It will be my endeavour to-day to show you some experiments illustrative of the enormous progress which was made during the years 1820 to 1830, resulting in discoveries which have formed the foundation of the whole of the most important developments and practical applications of electricity since that date. Previous to the years 1820 to 1830 there were but few phenomena connected with electricity really known. We knew that an electric current would heat up conductors. We knew that we could get a spark from charcoal points, and Humphrey Davy had made the celebrated experiment which led finally to the construction of the arc light. We also knew that chemical substances could be decomposed by means of an electric current. Beyond that practically nothing was known. A certain number of facts, isolated and non-reproducible apparently, had been collected. It had been found that there was some sort of connection between magnetism and electricity. But as to the nature of this connection nothing was known. It had, however, been observed that frequently on board ship, during a thunderstorm, when a flash of lightning struck a vessel the compass needle was either rendered useless or caused to point in an opposite direction—its north end pointing south, and its south end pointing north. It appeared, then, that this electric current, this passage of lightning, had some connection with magnetism. But till the year 1820 there was no clue as to what the connection between the two was. In our last lecture I showed you what an intimate connection there seemed to be between magnetism and electricity, and every step in our progress to-day will show the connection still closer. During the year 1883 there was a very grand exhibition of electrical appliances at Vienna, and I remember well in wandering round that enormous building in Vienna, where were collected the developments of electrical science in every department—in telegraphy, in telephony, in electric lighting, in electrical clocks, in short, in all kinds of electrical appliances—after having examined all the dynamo machines, arc lamps, &c., I came, in a select corner, upon a minute exhibit which made me pause with a feeling of respect and awe. When I looked at that small apparatus, and thought of the consequences which had followed from it, I say I looked upon it with respect and awe. It was simply a compass needle, placed on a stand, covered with velvet, with a glass shade over it, and above that compass needle there was the bust of the illustrious man who had made use of that simple apparatus. I need hardly say when I thought of the experiments that had been made with that apparatus, when I considered that from that single experiment the whole of the principles involved in the vast collection of electrical apparatus in that building almost immediately followed, I could not help feeling that there was something to have respect for. It is scarcely necessary to say that the exhibit I was looking at—that small compass needle—and the bust behind it, were those of Prof. Oersted, of Copenhagen. That experiment was the genesis of all that has been done in electro-magnetism since then. And I think you will be able to see this afternoon, as we take up one experiment after another, how it might have been possible almost to have foretold from that experiment a vast number of the phenomena which were discovered afterwards, and which form the fundamental principles of electrical science. The experiment of Oersted consisted in bringing a wire, through which an electric current was passing, into the neighbourhood of a suspended compass needle. Here I have a compass needle suspended on a pivot, and in my hand I hold a wire, through which I am able, when Mr. Davenport turns on the switch, to pass an electric current. [Shown] The direction of the current is shown by the arrow on this wire. The result is that, if the wire containing the current be held parallel to the needle, it should be deflected in one direction or the other, and the direction in which the magnet is deflected depends partly on the direction of the current, partly upon the position of the current above or below the needle. First, I place the current travelling from north to south, and I place the wire over the compass needle. You will then see that the north pole, which is the one towards my right, moves towards me. [Shown.] I now reverse the current, and make it travel from south to north, and immediately the motion is checked, and then a motion in the opposite direction is produced. By reversing the direction of the current I am able to reverse the direction of the deflection. [Experiment repeated.] Now let me show you what conclusion you might legitimately draw from this fact. The thing has nothing to do with the vertical position, except that the pivot being vertical the magnet can only travel in a horizontal plane. Therefore, we must not define the action as being dependent on the position of the current above or below. But we always notice this. I will give you a law which has been very largely used as a sort of aid to the memory—that if I be looking down thus, looking at the magnet, and if my body be lying in the direction of the current, so that I am, as it were, swimming with the current, the current coming in at my feet and out of my head, and if I be looking to the North Pole, I should see the north pole going to my left hand side. I will tell you another thing that follows immediately from this observation of Oersted. It follows that each one of these poles is trying to get round the current in opposite directions. When I have got the current above it, the north pole is trying to get round it, and it would go round it continuously, but it is restrained in its action by its connection with the south pole, which is at the same time trying to go round the wire in the opposite way. And, therefore, although both the north and south poles wish to go round that wire, they cannot go round in opposite directions because they are rigidly connected, and, consequently, they move into a position at right angles to the current. Therefore we see clearly enough that if we could arrange matters so that the north pole only was tending to go round the current, and the current did not extend over the south pole, then we should be able to get a continuous rotation of the north pole round the current. I think you will also agree with me that this is a conclusion that we should naturally have arrived at from the exhibit of Oersted's apparatus. I will try the experiment with a small apparatus which I have on the table here. This consists of a magnet which is in a bent form thus. [Shown.] The current comes down a pivot here, and is carried away by a wire placed in a trough of mercury here, and if our conclusion is right, that the north pole ought to travel continuously round the current, as I have already stated, then we should have a continuous rotation of this north pole round the current whenever it is turned on. The presence of the current is shown by the luminosity of that little bit of platinum wire which is bent round so as to dip into this cup of mercury. [Experiment.] I will now describe another experiment which is a still greater simplification of this, and a very remarkable one, too. Here I have a vertical magnet, which is pivoted at the top and bottom, and there is a platinum wire, as before, dipping into a cup of mercury, which carries away the current, so that the current only travels in this direction [indicated], and does not go near the south pole. In this way the north pole ought to travel round itself. [Experiment shown.] You see now that the north pole rotates round itself continuously. It appears, then, that so far as the action of a current is concerned, it is this—that there is a tendency to cause

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the north pole to move perpendicularly to the direction of the current, and to cause the south pole also to move perpendicularly to the direction of the current, but in the opposite way. In other words, a current has the power of creating a magnetic force in its neighbourhood—that is, of influencing the magnetic pole. If it has the power of creating a magnetic force, we know that it is capable of doing many other things. We know, for example, that it is capable of creating magnetic poles in a piece of iron. We also know, from the experiments we made on the last day—you remember when I threw images of some iron filings upon the screen—that the iron filings in a magnetic field indicated to us the direction of the magnetic force. So you will easily see that we ought, if we sprinkle iron filings round a wire, to be able to see the lines of induction of magnetic force as it circulates round the magnetic pole. Here is a wire coming up vertically through a hole in this piece of glass. I strew iron filings on the glass, and pass a powerful current through the wire. I now project an image of the arrangement upon the screen. You observe that the filings have formed a series of concentric circles around the wire. Now, what takes place when we have a coil of wire like this? What is the condition of the magnetic force when we have a coil of wire? We know that any part of a coil through which a current is passing is tending to move the north pole round it in a certain direction—continuously round it. Every part of this coil of wire is tending to move the north pole round it, and at its centre they all combine to move the north pole through the centre of the coil. You remember that when I had the small floating battery, with its coil of wire attached, that there was a tendency on the part of the magnet to suck this coil over itself. And now we see clearly that the opposite effect is capable of being produced, and that the coil would naturally tend to create a magnetic force through its centre, and the completion of the circuit would be accomplished round itself, outside, and back again through its centre. This action can do several things. The magnetic field thus created can cause a magnetic pole to move, so that, if we have a compass needle suspended inside [indicated], it would tend to twist it at right angles to the plane in which the wires of the coil are wound—that is, parallel to the axis of the coil, the north pole being moved through the coil in one direction, and the south pole in the other direction. This is the principle of the construction of the galvanometer, one of which I have on the table here. Here we have two coils of wire, both wound in the same direction, with a current circulating through these wires. At the centre of the stand there is a compass needle which naturally points parallel to the plane of the coils; but when the current is flowing, both these coils tend to move the north pole to the right, and the south pole to the left. This is one of the actions which a coil conveying a current of electricity can produce, owing to the magnetic condition of the space in its neighbourhood. Another thing which a magnetic force can do is to create poles in a piece of iron. Thus, if I put this piece of iron into the centre of this coil, as soon as the current is switched on it becomes a powerful magnet. In order to show you this I will support a few tacks in my hand under the iron. There is no attraction at present, but if Mr. Davenport will turn on the current these tacks will be attracted, as you see. At the moment the current is broken, the tacks fall down [so], showing that this coil, with a current passing through it creating magnetic force in its neighbourhood, is also able to induce polarity in a piece of iron. A third action is due to the combined effect of the two. This coil has the power when I suspend my iron by a piece of thread in front of and co-axial with the coil, of creating polarity in this piece of iron, and thus causing the pole to move towards the coil in accordance with the rules which we have seen before. [Experiment.] This sucking action is applicable to a great many kinds of apparatus, and I am illustrating this action more as an evidence of what we might expect would come from it than for any useful purpose it served at the time. Now I have said that a study of these phenomena, resulting simply from Oersted's grand discovery, would lead us to many new facts even before we had performed the experiment, and I am going to ask you to think about a further action, in order that you may be led to one of Faraday's beautiful discoveries, and, I believe, in so thinking over Oersted's experiment we shall be following somewhat in the direction in which Faraday proceeded. Faraday never told us that he knew what he was going to get first, but always described an experiment simply as it came. He did not wish to go in for hypotheses, but simply to show effects as they came. Now it is a grand law, which we have known since the days of Newton, that action and reaction are always equal and opposite. Let me say a few words here upon this. If one of you and myself were to sit upon two chairs upon castors, and to be connected with a rope, and I were to pull you towards me, you must not imagine that you alone would be pulled along the floor towards me, I also would be pulled towards you. If you were to pull alone, both of us would move in the same way. In every case whoever seems to be doing the work there is always a reaction equal and opposite to the action. When a planet is going round the sun, the planet is drawn towards the sun by the force of gravitation. But you must not suppose that the sun is not also drawn towards the planet. It most undoubtedly is; and although the mass of the sun is so great that its movement is very small, the total amount of reaction is exactly equal to the action of the earth towards the sun. When a stone falls from the hand to the ground, it falls by the force of gravitation, the earth attracting it; but the stone is at the same time attracting the earth, and the earth moves in the opposite direction to the stone, and the total action which we observe by the fall of the stone is exactly equal to the reaction in the motion of the earth upwards towards the stone, only the mass of the earth is so great that its motion is totally insensible. With these preliminary remarks, let us return to the experiments we have been considering. We find that a magnetic pole tends to rotate round an electric current. We know that action and reaction are always equal and opposite, and therefore we know, before we try the experiment, that a current will tend to rotate round a magnetic pole. Now, this is the sort of argument which I always imagine to myself Faraday must have used in studying Oersted's experiment, and leading up to the beautiful experiment which he produced, showing that an electric current rotates round a magnetic pole. This apparatus [indicated] is exactly the converse of the smaller apparatus which showed us the other experiments. Here I have a vertical magnet, with its south pole uppermost. Pivoted on the top of the magnet is a conductor, a piece of copper wire in fact, which travels parallel to the magnet, and dips down into a trough of mercury. The current enters parallel to the magnet, inside the trough of mercury, goes up to the top of the pole, traverses the pivot, goes down the wire which is parallel to the magnet, and outside it; then the current goes into the trough of mercury, and goes through a wire back to the battery. Now, when we turn on the current, we shall find that the wire is rotating round the pole, showing the accuracy of the principle that the action and reaction are equal and opposite. I will now simply show the effect of reversing the polarity. You notice the direction of rotation in the present case. If you were looking down upon it you would see that the direction is the same as that of the hands of a watch. I have now reversed the magnet and put the north pole uppermost, and we shall find that the current, instead of going in the direction of the hands of a watch, will tend to go in the opposite direction. [Shown.] This experiment led Faraday to a large number of very beautiful experiments, all illustrating the same points. But the general fact remains that, when we have an electric current in a magnetic field—that is to say, in a part of space where there is a magnetic induction—there is a force tending to move that current, and tending to move the magnet. A little more I should like to say about the direction. I told you when I was using the suspended magnet that the law for the direction of Oersted's experiment was that if you placed yourselves on a conductor carrying a current, with your head pointing in the direction of the current, and looked towards the north pole, that then you would see the north pole move to your left. Another way is: Place the face of your right hand towards the north pole, and point your thumb in the direction of the current; that is to say, the current is going down your thumb from the point of your thumb towards your hand, and the palm of your hand is facing the north pole, then your fingers will show the direction in which the north pole of the compass needle tends to move. That is perhaps a little simpler than the way I previously described it. Another way of remembering it has been put very justly and very properly in this way: Suppose that you are using a corkscrew, you turn it round in the direction of the hands of a watch, and at the same time the point is moving downwards. That gives you a relative idea between the direction of rotation and motion perpendicular to the plane of rotation. Then I would say that when a current is going in the direction in which a corkscrew moves—the forward direction—then the magnetic pole will be seen to turn in the direction in which the corkscrew turns. It is very easy to choose one of these rules, and fix upon it, but you are very apt to get confused if you do not fix on one. When you want to know in what direction a current moves, you have always to remember that action and reaction are always equal and opposite. Therefore, if, under these circumstances, the north pole tends to move in one direction, you know that under the same circumstances the current tends to move in the opposite direction. I am now going to another set of phenomena. The action of this coil upon a piece of iron is to magnetise it. Its action upon a piece of magnetised iron is to make the magnet move. The action of this coil is to create a magnetic field. The action of this coil is thus identical with that of a magnet. A magnet could be constructed of definite proportions, which would behave exactly the same way as this coil does. Now, if this coil attracts a magnet, and since another coil will act as a magnet, it is perfectly clear that two coils ought to attract each other. Each of these two coils is acting as a magnet [shown], and therefore they ought to be able to attract or repel each other, according to the position of their axis. They ought to be able to twist each other round a pivot, and this is part of the development of those grand researches which were undertaken by the French philosopher, Ampère. Ampère saw that there ought to be some action between conductors which carry currents of electricity, and on studying these actions he was able to bring out some very general laws. He aimed at putting his conclusions in a certain definite form. He supposed that when we have two circuits—whether they are coils or whatever they may be—with electric currents, he supposed that each little bit of a current in the one circuit was acting according to some force or another upon each small bit of the current in the opposite circuit, and that the action that we observed was the same upon all of those little independent currents. This was a very difficult way of attacking the problem, and he did attack it from a purely mathematical point of view. He showed that two bits of current parallel to each other either attracted or repelled each other according as the direction of the current in the two were the same or opposite. I have the means of showing this to you by a flat coil of wire which I have here suspended. This wire is simply wrapped round a central pivot until we get a spiral such as you see. [Indicated.] This is of considerable size, exposing a considerable surface which might be subject to an attracting or repelling influence. The suspension of this coil is effected by means of the wire itself. The two ends of the coil are conducted up to the beam over my head, and thence the wires go to the battery, so that I am able to send a current circulating through that coil. I have here another coil or spiral exactly similar to the one I have been describing. I have a separate battery also attached to this spiral. [Indicated.] The current is now circulating through the coil which is suspended. But there is no current at the present moment circulating through the coil which I hold in my hand. I now switch on the current in the second spiral, taking care that the connections are so made that the currents in the two spirals are in the same direction in adjacent parts. You observe

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that the spirals are attracted towards one another. [Experiment.] There, then, was a case in which the currents of electricity were circulating round these two coils in the same direction, and the parallel currents going in the same direction attracted each other. I will now ask Mr. Davenport to reverse the direction of the current of electricity, so that the currents in the two coils will be going in opposite directions. I will now hold my coil close to the suspended one, and you see there is a violent repulsion, and when I bring the two coils together they try to slide over each other and to get away from each other. There we had repulsion. I will now simply turn my coil round so as to bring the opposite face of the spiral towards this side, and ask Mr. Davenport to put on the current in the same direction as before, and you see there is attraction. You see that when I reverse the position of the coil I obtain the same effect as if I had reversed the direction of the current in the commutator. I will now show you by an apparatus on the table the truth of Ampère's conclusions—namely, that two parallel currents attract each other when they are going in the same direction, and repel each other when they are going in opposite directions. The apparatus which I have here consists of a vertical column, supporting at its top a pivoted horizontal wire, which is then bent downwards and dips into a trough of mercury at the base of the vertical column, so that this rectangular wire is perfectly free to rotate about a vertical axis. I shall be able to put on a current immediately, and the direction of the current I have carefully observed before—the current coming from the copper plate and going to the zinc plate through the external circuit comes up through this part. [Indicated.] The current of electricity in the wire which I hold in my hand is also going in the direction of the arrow which is attached to the conductor. The currents are now circulating, and I will keep the arrows pointing in the same direction. Both the currents are going in the same direction, and I bring this one near to the suspended one, and you see the action produced, causing a rotation of the whole apparatus round the central pivot, so as to bring that portion of the moveable circuit in which the current flows upwards as close as possible to this wire in which the current is also flowing in an upward direction, thus showing that two currents going in the same direction attract each other. I will now steady it, and hold my current in the opposite direction, and cause the current which I have in my hand to flow downwards, while that in the other is going upwards, and I think we shall be able to see a decided repulsion. [Shown.] The two main principles of Ampère's experiments are proved to be, very true, namely, that two parallel currents attract or repel each other, according as the direction of the current is the same or opposite. There is another part of Ampère's conclusions to which I will also direct your attention. He also showed us that if we take two wires, both carrying currents, and suspend them so that they are free to rotate about their centres, they will tend to attract each other if the currents are both going from the point of intersection. They will also attract each other where they are going towards the point of intersection. But if I have two wires in which the directions of the currents were like that [indicated on the board], in which one is going towards the point of intersection and the other is going from the point of intersection, Ampère showed that then there would be repulsion between these two. I have an apparatus which will show you this action very well. It is a very beautiful apparatus, which I happened to come across the other day. I have two coils of wire, both on vertical pivots, and capable of rotating about that vertical axis. A current of electricity can be independently sent through these two coils. Both of them in rotating are able to make contact with mercury which is contained in little cups. The ends of the one coil always dip into the same cups of mercury, and therefore the current always acts in the same direction through that coil. But the ends of the other coil dip into a cup which has a partition, and the mercury which is in the cup rises by capillary force above that partition, but not so as to flow over. Thus, we have two mercury sections into which the two wires can dip, and this acts as a commutator tending to reverse the action of the current. Thus the force is converted into repulsion, tending to continue the rotation. By this very ingenious device we can get continuous rotation of these two coils round the vertical axis, the two rotating in opposite directions. That illustrates the action which I have just been describing, showing the attraction or repulsion between these two cross conductors at the top and bottom of the pivot, combined with the attraction of parallel conductors which are at the sides. In conclusion, I will show you an experiment illustrating the same laws as Ampère worked out by means of another apparatus which I have there. But previous to doing so I wish to show you some of the models which have been lent to me, which illustrate the fundamental principles of Ampère's theory of magnetism. I have already shown you that a coil acts as a magnet, and the direction of a current in the coil is shown by these models. [Having explained the models referred to.] I shall now, in conclusion, show an experiment which further illustrates the attraction of currents for each other in a very simple way. I have upon a stand a spiral of copper wire forming a vertical coil freely suspended from its top. The lower end of the copper wire dips into a small vessel of mercury. When I turn on the current we know that there will be attraction between each one of these spirals and its neighbour, and the attraction is simply due to the creation of a magnetic field in the way in which we have evolved these views from Oersted's experiment. By the creation of a magnetic field there is attraction produced between these spirals. But if I were to put a piece of iron into the centre of it the intensity of the magnetic field would be increased. Whenever there is a magnetic field created there is attraction between the coils of this copper wire. If a current is passing through a spiral the current of electricity will be stopped as soon as this action has ceased to take place. Immediately the current ceases the spiral assumes its normal state.

(To be continued.)

ELECTRIC LIGHTING ACT, 1882, AMENDMENT BILL.

The following is the amended Bill, recommended by the Select Committee of the House of Lords, and intituled "An Act to Amend the Electric Lighting Act, 1882:"—

1. Section twenty-seven of the Electric Lighting Act, 1882, shall be read and construed as if the words

> "within six months after the expiration of a period of twenty-one "years, or such shorter period as is specified in that behalf in the "application for the Provisional Order or in the special Act, from "the date of the passing of the Act confirming such Provisional "Order or of such special Act, and within six months after the "expiration of every subsequent period of seven years, or such shorter "period as is specified in that behalf, in the application for the "Provisional Order, or in the special Act,"

had been originally ommitted from the sixth and following lines thereof and in lieu thereof the following words had been therein inserted:

> "within six months after the expiration of a period of forty-two "years, or such shorter period as is specified in that behalf in such "Provisional Order or special Act from the date of the commence-"ment of the Act, confirming such Provisional Order or of such "special Act, and within six months after the expiration of every "subsequent period of ten years, or such shorter period as is specified "in that behalf in such Provisional Order or special Act."

2. Notwithstanding anything in section twenty-seven of the Electric Lighting Act, 1882, the Board of Trade may by any Provisional Order to be made by them under that Act, if they think fit, vary the terms upon which any local authority may require the Undertakers to sell, and upon which the Undertakers shall be required to sell to such local authority their undertaking or so much of the same as is within the jurisdiction of such local authority under the said section, in such manner as may have been agreed upon between such local authority and the Undertakers.

3 (1.) Where in any case any electric line or other work may have been laid down or erected in, over, along, across, or under any street, for the purpose of supplying electricity, or may have been laid down or erected in any other position for such purpose in such a manner as not to be entirely enclosed within any building or buildings, or where any electric line or work so laid down or erected may be used for such purpose otherwise than under and subject to the provisions of a license, order, or special Act, the Board of Trade, if they think fit, may, by notice in writing under the hand of one of the secretaries or assistant secretaries of the Board of Trade, to be served upon the body or person owing or using or entitled to use such electric line or work, require that such electric line or work shall be continued and used only in accordance with such conditions and subject to such regulations for the protection of the public safety and of the electric lines and works of the Postmaster-General as the Board of Trade may by or in pursuance of such notice prescribe, and in case of non-compliance with the said regulations then the Board of Trade may require such body or person to remove such electric line or work: Provided that nothing in this sub-section shall apply to any electric line or work laid down or erected by any body or person for the supply of electricity generated upon any premises occupied by such body or person to any other part of such premises.

(2.) Where in any case any electric line or work is used for the supply of electricity in such a manner as to injuriously affect any telegraphic line of the Postmaster-General, or to affect the telegraphic communication through any such line, the Postmaster General may, by notice to be served upon the body or person owning or using or entitled to use such electric line or work, require that such supply be continued only in accordance with such conditions and regulations for the protection of the telegraphic lines of the Postmaster-General and the telegraphic communication through the same as he may by or in pursuance of such notice prescribe, and in default of compliance with such conditions and regulations the Postmaster-General may require that the supply of electricity through such electric line or work shall be forthwith discontinued. Provided that nothing in this sub section shall apply to the supply of electricity through any electric line or work laid down or erected under and subject to the provisions of any license, order, or special Act, or which may be used in accordance with any conditions or regulations prescribed by the Board of Trade by or in pursuance of any notice given by them under this section.

(3.) If any body or person fails to comply with the requirements of any notice which may be served upon them or him under this section, such body or person shall be liable to a penalty not exceeding twenty pounds for every such offence, to be recovered summarily, and any court of summary jurisdiction, on complaint made, may make an order directing and authorising the removal of any electric line or work specified in such notice by such person and upon such terms as they may think fit.

(4.) Any notice authorised to be served under this section upon any body or person may be served by the same being addressed to such body or person, and being left at or transmitted through the post to any office of such body or the usual or last known place of abode of such person, and any notice so served by post shall be deemed to have been served at the time when the letter containing the notice would be delivered in the usual course of post, and in proving such service it shall be sufficient to prove that the letter containing the notice was properly addressed and put into the post.

(5.) In this section terms and expressions to which by the Electric Lighting Act, 1882, meanings are assigned shall have the same respective meanings, provided that the term "street" shall include any square, court, or alley, highway, lane, road, thoroughfare, or public passage or place whatever, and the expression "telegraphic line" shall have the meaning assigned to it by the Telegraph Act, 1878.

(6.) Nothing in this section shall apply to any electric line or work

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of the Postmaster-General, or to any other electric line or work used or to be used solely for telegraphic or telephonic purposes.

4. This Act may be cited as the Electric Lighting Act, 1886; and the Electric Lighting Act, 1882, and this Act shall be read and construed together as one Act, and may be cited together for all purposes as the Electric Lighting Acts, 1882 and 1886.

COMPANIES' MEETINGS.

The Consolidated Telephone Construction and Maintenance Company (Limited).

The fifth ordinary general meeting of the Consolidated Telephone Construction and Maintenance Company (Limited) was held at the Terminus Hotel, Cannon-street, on the 10th inst. Mr. C. L. W. Fitzgerald presided.

The SECRETARY (Mr. Charles Curtoys) read the notice convening the meeting and the minutes of the last general meeting. The report, which has been dealt with in *The Electrician*, was taken as read.

The CHAIRMAN: Gentlemen, I hope I may be permitted to congratulate the shareholders on the improved aspect of the affairs of the Company. When I look back two years ago, and consider the position the Company was then in—how really hopeless everything seemed, with no money in the bank, and debts everywhere—and when we examine this balance-sheet in comparison with that of 1884, I think we have really the greatest cause for congratulation. Looking back to 1884, I see that the gross profits for that year were £5,600, and of that £5,000 was absolutely a compromise with the United Company; therefore, apparently, the manufacturing profits for that year were £600, while in the past year, as you see in the statement before you, they were £11,438. That item, too, would have been nearly £1,000 larger but for a question raised at the last moment by the auditors of the United Company as to the price of certain instruments. As far as I am aware, the Board of the United Company are sitting at this very moment to decide that matter, and I have reason to hope that the question will be decided in our favour. We propose that that £1,000 should be written off against the goodwill and patent rights. The next point I would attract your attention to in the report is a note as to the interest and dividends accrued on the holdings of the subsidiary companies. We have taken no credit whatever for that, though I think there is already something like £1,400 due, the greater part of which, I think, will be paid. The Austrian Company will certainly pay, and the Edison-Gower-Bell Company will probably pay a part of that interest. That, I think, is a matter of considerable importance to us, for you must remember that in the future we are looking to getting dividends out of our subsidiary companies. Further down in the balance-sheet you will notice plant and machinery, £3,097, and you will see that we have written off a considerable sum on that item. We have now got in the factory some more improved machinery from America, and, consequently, our machinery is in absolutely better condition than last year, and stands only at the same cost. As to our stock of instruments, &c., that stands at £3,303. The very tip-top firm in the electrical world in Germany have written us a letter, in which they say of some samples we submitted that the tests they have made with our instruments "prove that they may be classed among the very best that ever came under their notice." When I tell you that, and also that our stock is all of that kind, you may imagine that I look with some degree of satisfaction on that item. Lower down in the balance-sheet there is an item of £11,590 owing to us by subsidiary companies. That item includes a large sum which is due to us by the River Plate Telephone Company—£9,500. I will say no more on that head than you have seen in the report—that we believe we have at last come to terms of amalgamation with the opposition; and that to me is very gratifying, because throughout these fights the Consolidated Company has had to support the River Plate Company, through thick and thin, in cash, instruments, and stores. I do not think I need allude further to that side of the balance-sheet. Our investments are all going on well. On the debit side of the revenue account we have done everything we possibly can to reduce the expenditure. I think you will find that every item there shows a reduction as compared with last year. There are, however, four items which I should like to attract your attention to, and they are items which I do not think will occur again next year. They are—travelling expenses, £194; expenses in connection with Australian lawsuit, £167; commission on the sale of River Plate debentures, £280; and accountant's special charges for preparing balance-sheets, &c., £40. Those items in round figures come to something like £700. I only hope that in the next balance-sheet we present to you those items will not be there, and consequently, instead of the expenses being £3,695, they will be under £3,000. I do not think I need say anything more on the figures. The gross profits for the year amounted to £13,473, and I may say that that profit has been collected from all parts of the world, from a few of our colonies, and I was extremely gratified, I must say, at getting two orders from America. I did not, I must confess, expect that we should go into the enemy's country in that way, but we did so, and I hope and trust that we may get more orders from that quarter. Our business is slowly and steadily extending, and I attribute that fact to the absolute goodness of our manufactures. I could show you heaps of testimonials on that head, all of which are very gratifying to the Board. In addition, we are really supplying the subsidiary companies in England with certain articles—magneto bells, and other little bells, and so on, which all mean profit to us. We have started agencies in Madrid, Cadiz, and Naples, and I think I may say that in course of time these agencies will become very valuable outlets for our business. At first I always find abroad the same thing—the price is too dear; but within the last six weeks we have been asked whether we would undertake to erect an exchange in a town in Spain, and from that it would appear that they were beginning to recognise the fact that superiority of instruments amounts to something. You will notice that we have obtained a return of income-tax—that some money we had paid we have got back. The next item is the lawsuit which Colonel Gouraud has started against the Company for his fees. We are advised that we have got a very good

THE UNITED TELEPHONE COMPANY (LIMITED), AND ITS SUBSIDIARY COMPANIES.

The following particulars of capital, &c., and price list have been sent us by Messrs. Bell, Begg, and Cowan, of 10, North St. David-street, Edinburgh:—

COMPANY.	CAPITAL.					DIVIDEND.				LATEST PRICE.
	AUTHORISED	ISSUED.				RATE PER CENT. PER ANNUM.				
		SHARES.		CALLED UP.		1884.		1885.		
		Number.	Amount	PerShre	Total.	1st ½ year.	2nd ½ year.	1st ½ year.	2nd ½ year.	
UNITED	£500,000	80,000	£5 0 0	£5 0 0	£400,000	5%	15%	4%	...	13⅛
(Incorporated 3rd June, 1880.)		19,022	5 0 0	2 10 0	47,555	(interim) 5%	15%	(interim) 4%	...	7¼
LANCASHIRE & CHESHIRE	400,000	300,000	1 0 0	1 0 0	300,000	6%	7%	7%	7%	27/-
(Incorporated 21st May, 1881.)		100.000	1 0 0	0 4 0	20,000	...	New Issue.		7%	7/6
NATIONAL	*750,000	90,000	5 0 0	5 0 0	450,000	1½%	2%	2½%	3%	77/6
(Incorporated 10th March, 1881.)		15,000 6% 1st Pref.	10 0 0	10 0 0	150,000	6%	6%	6%	6%	11⅜
		15,000 6% 2nd Pref. (Minimum.)	10 0 0	2 0 0	30,000	...	New Issue.		6%	47/3
NORTHERN DISTRICT	100,000	15,000	5 0 0	5 0 0	75,000	nil	nil	nil	nil	...
(Incorporated 13th December, 1881.)		1,088 (6% Pref.)	10 0 0	10 0 0	10,880	6%	6%	6%	6%	...
SOUTH OF ENGLAND	400,000	300,000	1 0 0	1 0 0	300,000	...	...	...	nil	6/3
(Incorporated 29th January, 1885.)		6,433 (6% Pref.)	5 0 0	1 10 0	9,649 10/	...	...	...	6%	25/-
TELEPHONE COMPANY OF IRELAND	250,000	175,000	1 0 0	1 0 0	175,000	1%	3%	3%	3%	5/-
(Incorporated 27th May, 1882.)		14,996 (5% Pref.)	1 0 0	1 0 0	14,996	†5%	5%	5%	5%	17/-
		29,794 (5% Pref.)	1 0 0	0 12 6	18,621 5/	5%	5%	5%	5%	10/-
WESTERN COUNTIES AND SOUTH WALES	400,000	275,000	1 0 0	1 0 0	275,000	...	...	nil	nil	7/-
(Incorporated 17th December, 1884.)		6% Pref. 3,671	5 0 0	5 0 0	18,355	...	...	6%	6%	5
		6% Pref. 170	5 0 0	2 10 0	425	...	...	6%	6%	...
		6% Pref. 5,879	5 0 0	2 0 0	11,758	...	...	6%	6%	2
		6% Pref. 280	5 0 0	1 0 0	280	...	...	6%	6%	...

* This company has also issued £75,000 debentures, bearing interest at 5 and 6 per cent.

† Small number of shares received 6%. (Note—25,000 6% preference shares, £1 each, 10s. paid, were originally used, but have since been converted into 5% preference shares of £1 each, fully paid, at the rate of 120 per cent.)

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defence indeed for a very considerable portion of the claim that Colonel Gouraud brings against us. You will observe that the directors intend to ask you to permit us to assist the Edison-Gower-Bell Telephone Company in protecting the patent rights owned by that company in Belgium. That is a very, very important question. I could not tell you how much the sum of money involved in it is, but when I tell you that our greatest opponent, the manufacturing company over there, are turning out large numbers of instruments, every one of which is an infringement of the patents held by the Edison-Gower-Bell Telephone Company you will realise that it is an important matter to us that, if possible, we should stop these infringements. Of course, you may rest quite assured that we shall not spend a penny more than is necessary, and we shall only go into this matter if we feel our ground very safe. Law, of course, is a very uncertain thing. You never can say what is going to happen in a law suit. This particular Edison patent, however, is the master patent in England and also in America. We are, therefore, going to propose a resolution to the effect that you allow us to assist the Edison-Gower-Bell Telephone Company. I should tell you that if we assist the Edison-Gower-Bell Company it will be on the understanding that we get half the profit made on the transaction—half the loss and half the profit. I am now coming to what, in my mind, is the most satisfactory part of the whole report—that is, the amalgamation of the River Plate Telephone Company. I think I had better say as little as possible on that point, as we have only signed the preliminary agreement, and therefore it is possible that I might say something that would do us no good. The next paragraph refers to the increase in the subscribers and rental of the subsidiary companies, and that is a subject which ought, perhaps, to be regarded by the shareholders as equally beneficial. I do not know whether any of the shareholders have examined this report very carefully as far as regards adding up the amount of the ordinary shares, the preference shares, and the debentures that we hold in the various companies; but if they do so they will find that we, the Consolidated Company, hold £66,000 in these three companies that are mentioned. Now, these are beginning to return us money, and if I mistake not they will this year return us more money, especially if this River Plate amalgamation takes place; and I am even hopeful that in the future the large sum which stands here—which is taken at absolutely nothing—£222,580 in the ordinary share capital of the subsidiary companies, may return us some income. In the case of the Austrian Company, I am quite certain that they will do so in course of time, and I believe the River Plate Company will also if the amalgamation takes place. Consider for a moment what that £66,000 of debentures and preference shares means. Even if we only get 5 per cent. on that amount it would mean that the whole of our fixed charges would be paid by that return, which would also mean that we should be able to divide up every penny profit on the manufacture of instruments. As you know, I have always had my eye fixed on these subsidiary companies. They must be pushed at all hazards, because they mean that we shall eventually receive large dividends. Anyone, I think, who knows anything about the telephone will at once realise that people do come forward for it in the most marvellous manner. If I return to this Austrian report, I may say that two years ago—18 months ago, even—we had only 600 subscribers there, and now we have got 1,373 subscribers. I assure you that they are coming forward almost too rapidly for us in Austria, because you cannot put up wires and instruments and so on without capital, and these people are coming forward so rapidly that there is some difficulty in finding the capital that is requisite to meet their demands. While on that point I would say that the Board of the Austrian Company propose issuing some 6 per cent. preference shares. If the shareholders in the Consolidated Company wish to assist the Austrian Company and also themselves, they will assist the Austrian Directors by taking some of these preference shares. My father and I have a considerable stake in the Austrian Company, but personally I feel disposed to put some more money in it, as I think it is as good a thing as I know of. I hope it you receive a circular from the Austrian Company you will—some of you at any rate—respond by taking some of the shares. He concluded by moving the following resolution:—"That the statement of accounts and balance sheet, and the report of the Directors as now submitted to the meeting be received and adopted, and that a final dividend of 2½ per cent. be paid, making with the interim dividend previously paid, 5 per cent. for the year ended March 31, 1886."

Sir ALEXANDER ARMSTRONG, K.C.B., seconded the motion.

Mr. KLENCK asked what the probable cost of the litigation referred to by the Chairman would be, and what would be the probable result.

The CHAIRMAN: We have already gone a good deal into this question before even dreaming of bringing it to your notice. So far as we know, we think the probable cost would be about £2,000. The probable profit I really could not tell you. It means very many thousands of pounds as you can imagine for yourselves. The United Telephone Company have the patent rights for England, and if the Edison-Gower-Bell Company get the patent rights for Belgium it will be a very "big" thing, because these infringers would have to pay us compensation for what they have done in the past. That is the Belgian law, I know, for I have studied it. You may be certain that we should not recommend you to go into anything unless there were a prospect of our obtaining something very tangible.

Mr. KLENCK: Do I understand that our total contribution to the cost would be about £2,000?

The CHAIRMAN: No, our share would be £1,000. The total cost would be about £2,000. In answer to another shareholder he stated that, as the revenue account showed, they had received in cash by way of dividends and interest on investments £1,588, which did not include interest accrued. They had transferred the £6,000 reserve against the general business of the Company instead of against a particular item.

Mr. TRAVERS asked whether the opposing company in Belgium were rich, or were worth "powder and shot?"

The CHAIRMAN: Well, gentlemen, I only wish we were as rich.

A SHAREHOLDER pointed out that the Belgian Company alluded to had been supplying instruments not merely in Belgium, but all over Europe.

The CHAIRMAN then put the motion in the usual way and declared it carried unanimously. Continuing, he said: The next resolution is: "That the Directors be authorised to take such steps as they may think desirable in connection with the Edison-Gower Bell Telephone Company of Europe for the protection of their patent rights in Belgium."

Mr. KLENCK: May I add, "At an expense not exceeding £1,000?" ["No, no."]

The CHAIRMAN: I think that would be hazardous. You may rely upon it that we shall not spend more than we can possibly help.

Sir A. ARMSTRONG seconded the motion, which was carried unanimously.

The CHAIRMAN then proposed the re-election of the retiring Directors, Sir A. Armstrong and Messrs. A. H. Baker and H. Grewing.

Mr. KLENCK: Do they all attend?

The CHAIRMAN: I will say this for the Board that I have the pleasure of presiding over—that I think it is quite exceptional for any member not to attend.

Mr. JOHN TAYLOR seconded the resolution, which was carried unanimously.

On the motion of Mr. T. LLOYD, seconded by Mr. FELDHEIM, Mr. J. G. Griffiths, F.C.A. (of the firm of Messrs. Deloitte, Dever, Griffiths, and Co.), was re-elected an auditor; as was also Mr. A. E. Green, on the motion of Mr. R. E. WYATT, seconded by Mr. GARDINER.

Mr. LLOYD then proposed a vote of thanks to the Chairman and Directors. He thought that after the very flattering statement which the Chairman had made, they would all agree with him that they owed something more to the Chairman and the Directors than a mere vote of thanks, especially so when they looked back on the former position of the Company. Only two years ago they were in such a position that they were practically losing their manufacturing business, their capital was gone, and their shares were down at 2s 6d. Their position now was very different, and as the result of last year's working the Directors were enabled to pay a dividend of 5 per cent. Their business was also rapidly improving, and they saw that the subsidiary companies were coming forward rapidly to the front; while, if they looked at their prospects, he thought they were even better than the Chairman—in his cautious anxiety not to raise their hopes too high—had said. They all appreciated the Chairman's caution, but they could see by their accounts that the position of the Company was most gratifying; and what made it all the more gratifying was that the change that had taken place, in so short a period as two years, was not due to any fluke or any outside incident. It had simply been brought about by thoroughly good management. They had now a Board who had proved for two years that they fully deserved the warmest thanks of the shareholders. There were one or two points to which he especially desired to draw their attention. The Chairman had stated that practically if things went on smoothly, as there was every prospect of, their dividends and interest from the subsidiary companies would cover the current fixed expenses of the Consolidated Company, so that the whole of their manufacturing profit would be divisible among the shareholders. He believed he was correct in saying that the organisation of their factory was such that they did not require to lock up their capital—that practically as soon as they were called upon to pay for goods they themselves received payment for them. They had therefore no real liability. He believed he was correct in that statement.

The CHAIRMAN: There is a certain sum of money locked up in stock, of course, but that is continually being used up and replaced. That is the ordinary course of business. We are not locking up money in useless, obsolete stock. We keep as little stock as possible, so that we can always be ahead of the trade, so to speak, in all improvements.

Mr. LLOYD said that what he specially meant was that they did not need to invest in any large amount of stock.

The CHAIRMAN: No.

Mr. LLOYD, continuing, said that the organisation of their property was such that they did not need to lock up thousands of pounds in order to execute orders when they came in, and the payments which they had to make were met by what they had to receive. The amount due to them was £18,000, of which £8,000 would be payable very soon, and might be regarded as a perfectly good debt. The £9,500 to which the Chairman had referred was owing by a company of which he (Mr. Lloyd) happened to know something, and he thought he could safely say that it would be paid by-and-bye.

Mr. KLENCK seconded the motion, which was carried unanimously.

The CHAIRMAN, in reply, said it was very gratifying to his colleagues and himself to find that their services were appreciated by the shareholders. He could only say that they meant to go on in the future as they had in the past. He might add that they would post the dividend warrants this week.

The proceedings then terminated.

COMPANIES' SHARE LIST.

TELEPHONES.

COMPANIES.	CLOSING PRICES. JUNE 9.		BUSINESS DONE WEEK ENDING JUNE 9. Highest.		Lowest.	
Consolid. Telephone and Maintenance..	13-16	15-16	.....	—	.....	—
Oriental	3-16	5-16	.....	—	.....	—
United Telephone	13⅛	13⅛	.....	13 13-16	.....	13⅝

MISCELLANEOUS.

Telegraph Construction	37½	38½	.....	38½	.....	—
India Rubber, Gutta Percha, and Telegraph Works	22½	23½	.....	23¼	.....	23 1-16

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TELEGRAPHS.

Companies.	Closing Prices. June 9.		Business Done Week Ending June 9. Highest.		Lowest.	
Anglo-American	32,	37	32¼		—	
Do. Preferred	53,	54	53½		53	
Do. Deferred	10⅜,	11¼	11		10 9-16	
Brazilian Submarine	10½,	10⅝	10⅝		10½	
Cuba	10¼,	10⅜	10¼		—	
Do. Preference	18,	19	—		—	
Direct Spanish	1½,	2	—		—	
Do. Preference	9,	10	—		—	
Direct United States Cable	9,	9¼	9 3-16		8⅞	
Eastern Telegraph	10⅞,	11	10 15-16		10⅝	
Do. 6 per Cent. Preference	14¼,	14⅞	14½		14¼	
Do. 5 per Cent. Debentures, 1899	105,	108	—		—	
Eastern Extension	12⅛,	12⅜	12⅜		12	
German Union	9½,	9¾	—		—	
Globe Telegraph and Trust	6½,	6⅞	6 11-16		6¼	
Do. Preference	13¼,	13⅝	13⅝		13¼	
Great Northern	12½,	13¼	13¼		12½	
Indo-European	33½,	34½	—		—	
Reuter's	6,	6½	—		—	
Submarine	200,	210	200		—	
West India and Panama	½,	¾	—		—	
Do. 1st Preference	8,	8½	8 7-16		8¼	
Western Brazilian	7⅛,	7⅜	7⅜		—	
Western Union 7 per Cent. 1st Mortgage	118,	122	—		—	
Do. 6 per Cent. Sterling Bonds	103,	107	—		—	

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	2,	2½	—		—	
Do. (fully paid)	3½,	4½	—		—	
Swan	1⅜,	1⅝	1 9-16		1½	
Maxim-Weston	3-16	5-16	—		—	

TRAFFIC RECEIPTS FOR MAY, 1886.

Companies.	May, 1886.	May, 1885.	Increase.	Decrease.
Cuba Submarine	3,050	3,736	—	686
Direct Spanish Telegraph	1,688	1,352	336	—
Eastern Extension	41,037	50,016	—	8,979
Eastern Telegraph	50,741	61,327	—	10,586
Great Northern	22,480	—	—	—
West Coast of America	3,450	—	—	—

CRICKET.

LANCASHIRE AND CHESHIRE TELEPHONE COMPANY.

MANCHESTER V. LIVERPOOL EMPLOYÉS.

This match was played at Liverpool on June 5, and after a most enjoyable game resulted as given below. After the match the visitors were very kindly entertained to dinner by the Liverpool Club.

MANCHESTER.

Partington, b. Bunting	3
Hodgkinson, c. Cook, b. Bunting	10
A. Pugh, b. Bunting	0
Poole, b. Huxley	2
Beer, b. Bunting	0
Hibbert, b. Bunting	19
Collins, run out	1
Scott, c. Magnall, b. Bunting	5
M'Pherson, b. Bunting	0
W. Pugh, b. Sharp	0
F. F. Bennett, not out	0
G. Bennett, b. Huxley	1
Extras	15
	—56

LIVERPOOL.

France, run out	5
Clough, c. Beer, b. A. Pugh	1
Bunting, c. G. Bennett, b. A. Pugh	13
Sharp, b. A. Pugh	6
Martin, c. Hodgkinson, b. A. Pugh	0
Huxley, b Hodgkinson	7
McKie, b. Pugh	0
Roberts, c. Hibbert b. Hodgkinson	0
Magnall, c. Beer b. Hodgkinson	0
Jackson, b. Hodgkinson	0
Drummond, not out	0
Cooke, b Pugh	5
Extras	3
	—40

THE SCHOOL OF SUBMARINE TELEGRAPHY AND ELECTRICAL ENGINEERING.

ESTABLISHED IN 1868.

12, Princes Street, Hanover Square, London, W.

Manager: Wm. LANT CARPENTER, B.A., B.Sc., F.C.S.

THIS Establishment is not only the largest School devoted exclusively to Electrical Engineering in its widest application, and is supplied with numerous dynamo machines, lamps, artificial cables, &c., it is also the only one in which a lengthened experience of the difficulties and requirements of an effective course of tuition and training has led to success, in supplying capable men in every branch of applied Electricity. Since the opening of the School in 1868 upwards of 3,000 Pupils have passed through the course. At the end of the course of instruction, an Examination for the CERTIFICATE OF THE SCHOOL is conducted by an Examiner of very high standing, unconnected with the School. Copies of Testimonials from gentlemen of the highest eminence, both as Scientific and Practical Electricians, can be had on application.

TESTS MADE AND REPORTS FURNISHED.

For full prospectus, terms, &c., apply to the Secretary, 12, Princes Street, Hanover Square, W.

THE

THOMSON-HOUSTON SYSTEM OF ARC LIGHTING.

Extract from the "Times," Saturday, June 5th, 1886:—

"THE EDINBURGH INTERNATIONAL EXHIBITION."

* * * * * * * * * * * * * * * * *

"Electric lighting forms so important a feature of the Exhibition that some notice of the different systems employed may be useful."

* * * * * * * * * * * * * * * * *

"There can be no doubt that, both for brilliancy and steadiness, the palm must be given to the THOMSON-HOUSTON lamps. The grand hall and the picture galleries are as brightly and as pleasantly lighted by night as they are by the noonday sun. Between the other systems of arc lamps I cannot venture to discriminate. They are all good, though none of them can be compared with the THOMSON-HOUSTON SYSTEM."

LAING, WHARTON & DOWN,

8 and 9, Holborn Viaduct, London.

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NOTES.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 11th inst. amounted to £2,756.

AMERICAN EXHIBITION.—President Cleveland has accepted the presidency of the American Exhibition, to be opened next year at South Kensington.

STRIKE AT EDISON'S.—We understand that the dispute which resulted in a temporary strike has been arranged, and the strike has come to an end.

MATHEMATICAL SOCIETY.—A paper was read at the last meeting of this society entitled "Electrical Oscillations on Cylindrical Conductors," by Prof. J. J. Thomson, F.R.S.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 11th inst. were £2,194, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

TELEPHONE GUIDE BOOK.—The National Telephone Company have issued their guide book, containing a list of the subscribers to the Glasgow Exchange, for the month of June, which, as usual, is replete with information in regard to the service of the company.

MINING INSTITUTE OF SCOTLAND.—At a recent meeting of the members of this institute an interesting paper describing a new American method of indicating temperature, steam pressure, &c., by means of electricity was read by the secretary, and led to an important discussion.

NEW COMPANY.—A new company is being promoted at Bradford with the object of enabling the shareholders to provide lighting by electricity to certain detached blocks of buildings. The prospectus indicates that the company is intended more as a co-operative venture than an ordinary business company.

THE NEW TARIFFS.—The Eastern Telegraph Company has issued a card giving a complete list of its rates to come into force on the 1st of July. Important reductions of tariff will be made not only to all countries in Europe, but also to India, Siam, Cochin-China, China, Manila, Japan, Australia, Tasmania, and New Zealand.

ELECTRIC LIGHT IN PARIS.—The preparations for the electric lighting of the Exposition de la Société des Sciences et Arts Industriels are being actively carried on by M. H. Fontaine, who is ably assisted in the work by M. G. Fournier. The number of Jablochkoff candles to be installed in the Palais de l'Industrie is fixed at 160.

ELECTION INTELLIGENCE.—Mr. John Pender, chairman of the Eastern Telegraph Company, has decided to oppose Mr. H. Campbell-Bannerman in the election for the Stirling Burghs. Mr. John Denison Pender, son of Mr. John Pender, will come forward for the Wick Burghs as a Unionist Liberal against Mr. J. Macdonald Cameron, the sitting member.

ELECTRICAL SUBWAYS.—The members of the Commission on Electrical Subways in New York state that the mileage of wires in that city overhead reaches 14,556 miles, to which must be added 1,006 miles underground, giving a total of the mileage in use, according to the statements made by the various electrical companies, of 15,562.

TELEPHONE AT GIBRALTAR.—The English Government, it is said, have authorised the installation of a telephonic system at Gibraltar. The concession has been accorded to Messrs. Spagnoletti and Crookes, who will follow the system generally adopted in England. The subscription will be 250fr. per year. An office will be specially fitted up for commercial men upon the quay.

ELECTRIC LIGHTING AT BIRKDALE, LANCASHIRE.—The Local Board for the district of Birkdale invite tenders for an installation of the electric light for lighting the public lamps of the district. Applications for particulars must be made not later than the 26th instant. Tenders are to be sent in, free of cost, on or before the 24th July next. Full particulars will be found in our advertising columns.

CRAIG-Y-NOS CASTLE.—The residence of Madame Nicolini—as we must now call her—better known as Madame Patti, is lighted by the electric light. A gas engine of six horse-power is used for driving the dynamo generating the current. The castle is lighted by about 150 Swan lamps, most of the rooms, except the bed rooms, being so lighted. Besides the electric light, a small gas works is connected with the castle, supplying the gas required for cooking purposes.

WHO IS THE MAN ?—Our American namesake says the battle in Detroit between the Brush and the Thomson-Houston electric light companies was waged with all the earnestness of a Continental strife. Some hot shot was delivered by both sides, but the hottest thing was the undisputed statement of a London scientist, whom the Common Council had brought upon the scene—that the arc lights for which 2,000 candle-power was claimed never produced 500 candle-power.

ROYAL SOCIETY.—The following are the new members who have been elected into the Royal Society:—Shelford Bidwell, M.A.; William Colenso, F.L.S.; Harold B. Dixon, F.C.S.; Major-General Edward Robert Festing, R.E.; Andrew Russell Forsyth, M.A.; Prof. A. H. Green, M.A.; Prof. Victor Horsley, F.R.C.S.; Raphael Meldola, F.R.A.S.; Philip H. Pye-Smith, M.D.; Henry Chamberlaine Russell, B.A.; Adam Sedgwick, M.A.; Prof. W. Cawthorne Unwin, B.Sc.; Robert Warington, F.C.S.; Captain William James Lloyd Wharton, R.N.; Henry Wilde.

THE SLATTERY CUT-OUT.—A remarkable test was recently made at the office of the Brush Electric Light Company of Boston with the Slattery cut-out for incandescent lamps in multiple series. The circuit had an E.M.F. of 3,000 volts. The distributor was attached to two multiples of eight lamps each. On turning on or off the ninth lamp (*i.e.*, the first of the second multiple) an automatic switch throws the second set of lamps in or out of series. The inventor removed a lamp and broke the connection of the bare wires without receiving the slightest shock.

THE IMPOSSIBLE.—After the Keely motor, one of the wonders that attract the attention of the American public is the Gray dynamo electric machine. It is claimed that tests have shown that this machine gives enough current for six 2,000 candle-power lamps for one mechanical horse-power. It is further stated that it is the intention of the inventor to utilise this current in suitably constructed electro-motors, and thereby to obtain four or five horse-power from the motors to one horse-power used in driving the dynamo. A portion of the power generated by the motors is utilised in driving the dynamo, it being only necessary to start the dynamo at first by some outside force.

THE ELECTRIC LIGHT AT COLCHESTER.—At a special meeting, held last week, the Colchester Town Council had under consideration the subject of the electric lighting of the borough. It appears that a new company has been formed for taking over the plant and business of the South Eastern (Brush) Electric Light Company, by whom the original electric lighting experiment was carried out in the town. The new company has been incor-

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porated, but before commencing business it is, of course, necessary that the license granted to the old company by the Board of Trade should be properly transferred to the new one. The Sanitary Committee of the Corporation have already passed a resolution for the extension of the necessary powers to the new company, but the council show some reluctance in ratifying it. The matter is to be further considered.

COMPETITION AND COOL DRINKS.—With the returning summer and increasing severity of competition an enterprising New Jersey chemist, whose store is also a Baltimore and Ohio telegraph office, has renewed the beguiling inducements offered last year by him to persons about to wire, in the following terms:—"Opposition the life of trade. A delicious glass of soda water given away with each telegram sent *vid* B. and O. Telegraph Co. We call the attention of the public to the fact that the B. and O. Telegraph Co. has been the means of bringing low rates and breaking up monopoly. Telegraph with the B. and O. Telegraph Co., save money, and keep cool with a glass of ice cold soda water, given away with each telegram sent *vid* B. and O. Telegraph Co. from the handsome fountain at Van Brunt's Pharmacy, Front-street, Red Bank, N. J."

THE ASTRONOMICAL DAY.—According to the report of the Science and Art Department a number of letters were addressed to the various authorities, in order to obtain their opinions as to the twenty-four hours per day system. A number of replies were received, among which were those from the Eastern Telegraph Company and the Eastern Extension Company, which stated that they have always adopted the twenty-four hours' system in timing their messages, and thus avoided the necessity of signalling the letters "a.m." and "p.m." The Society of Telegraph-Engineers approve the first resolution of the Washington Conference, but reserve their opinion on the one referring to the application of the decimal system to space and time. The Eastern and South African Telegraph Company follows the same system as the Eastern and Eastern Extension. The Submarine Telegraph Company does not adopt the twenty-four hours' system.

NEW YORK TAXES.—In whatever part of the world we may happen to be, the taxgatherer is by no means a pleasant caller, and we have no doubt that many companies would prefer that there were no such things as taxes to be paid. The municipal taxation in New York is 2·4 per cent., and the amount of taxes levied upon electrical interests in the city amounts to over 38,000 dollars. The largest payment seems to be that of the Metropolitan Telephone and Telegraph Company, a little over 6,398 dollars. The United States Electric Lighting Company pays some 5,889 dollars, the Edison Electric Illuminating Company running them close with 5,223 dollars, while the Edison Lighting Company pays 3,824 dollars. The British Electric Illuminating Company pays 1,824 dollars. The Western Union Telegraph Company pays 2,232 dollars. Several other companies pay over 1,000, and the last and the least is the American Speaking Telephone Company and the Equitable Electric Company running a dead heat, each paying 4 dollars 80 cents.

THE GOOLDEN AND TROTTER DYNAMO.—It is not often that three independent individuals hit upon the same idea almost simultaneously. A new type of dynamo, so far as the arrangement of the magnets is concerned, has been introduced by Messrs. Goolden and Trotter. A very similar pattern has been recently produced by Mr. Kapp, and it appears that an American inventor is working on the same lines. The dynamo may be described as having an Edison field, in which the yoke as well as the bars are wound. A number of these have been mounted with Messrs. Heenan and Froude's tower spherical engine, for use on the sea-going torpedo boats, the combination being probably the smallest for its weight, speed, and output that has ever been produced. The dimensions over all are—Height, 2ft. 3in.; length, 3ft. 6in.; width, 1ft. 6in.; weight, with bedplate, lubricators, &c., 8 cwt. The output is 60 amperes, 60 volts, 650 revolutions at 90lbs. steam. The engine and dynamo are easily capable of producing 4,000 watts at 700 revolutions.

FRENCH PRIZE COMPETITION.—Among the subjects put down for the prize competition for the year 1887 by the Société d'Encouragement we note the following, which are of peculiar interest to those of our readers who are of an inventive turn of mind:—A prize of 2,000fr. for a small motor designed for a family workshop to be worked separately or to be connected with a central factory. A prize of 3,000fr. for a medium of transporting to a considerable distance natural mechanical powers which their actual position does not allow of being immediately utilised. A prize of 3,000fr. for the invention of a simple and substantial appliance capable of indicating automatically in a sure and regular manner at a given distance the speed of a railway train. A prize of 3,000fr. for the construction of an instrument for transmitting to a distance an indication of the temperature of a heated enclosure. A prize of 3,000fr. for the discovery of a perfect process of transmitting to a distance motive power to agricultural machines. Competitors must send in their contributions before the 1st of January next.

THE "COMMERCIAL CABLE."—The following is the letter referred to in our leader:—"We respectfully tender our thanks to those of our friends and customers who have notified us of their intention to support the Commercial Cable Company during the impending tariff contest. The very large number of communications which we have already received renders it impracticable for us to make separate acknowledgment to each. We trust, therefore, that all will accept this public announcement of our appreciation of the large and cordial support thus assured to us in advance. A few of our friends have asked us what assurance of protection we can offer to them in case the patronage extended should not be sufficient to enable us to withstand the attack now made upon the company. Recognising the propriety of such inquiry, we now announce that in the event of our being compelled to advance our rates *beyond those which we have heretofore charged*—40 cents per word—we will refund the amount of excess that may have been paid to us during the continuance of the struggle, viz., the difference between 12 and 25 cents per word between America and Great Britain and France, and the difference between 15 and 25 cents between America and Germany."

METEOROLOGICAL.—The great interest in meteorological observation and weather prediction which has been fostered by the Signal Service Bureau is well illustrated by the proposed action of the New England Meteorological Society. The latter, says the *Electrical World*, aided by numerous volunteers, to the number of 300, has determined to make a close study of thunderstorms during the three months beginning June 1st. A special feature of the work is found in the appointment, in advance of certain days, to be called term days, on which thunderstorms may be expected in some parts of New England, and on which all observers are to make certain systematic records. These term days will be appointed by the Signal Office in Washington, and the announcement of them will be sent by telegraph to all newspapers in New England belonging to

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the Associated Press or the United Press. An extended publication will thus be secured, and the appointments will be brought to the notice of all observers. Such systematic study by numerous observers, widely scattered, cannot fail to establish results of the greatest value. The science of meteorology, and weather prediction especially, has been greatly developed in this country, and the benefits derived therefrom are becoming more and more manifest.

TELEPHONE EXTENSION.—We understand that within the next fortnight the Western Counties and South Wales Telephone Company will open their Telephone Exchange in Swansea, having secured convenient premises at the bottom of Wind-street in proximity to the docks and merchants' offices. In addition to the network of wires which will be gathered into and ramify from the new Swansea Exchange for the accommodation of the local business which is likely to speedily accrue upon the extension of this great convenience of modern life, there will be direct communication with Llanelly at once, and within a short time the new company's wires will extend to Landore, Neath, Aberdare, and thence through Newport, we believe, to Bristol. Mr. H. F. Lewis, the general manager and secretary of the company, has been in Swansea during the present week perfecting arrangements. The directorate, as we have previously had occasion to notice, is a very influential one, including some of the leading commercial men of Bristol and Cardiff. The Swansea Commercial Exchange is intended to be open both night and day, Sundays excepted. The convenience of having electrical communication with an exchange, and through it with the police and the hospital at night, and with numerous business firms by day, is so apparent, that within measurable time every considerable house will be so connected.

SOCIETY OF ARTS.—The Council of the Society of Arts have awarded the society's silver medal to the following readers of papers during the session 1885-86:—To Prof. Francis Elgar, LL.D., for his paper on the load-lines of ships; to Henry Davey, for his paper on machinery in mines; to Prof. W. C. Unwin, for his paper on the employment of autographic records in testing materials; to C. V. Boys, for his paper on calculating machines; to Prof. Leonard Waldo, D.Sc, for his paper on watch-making by machinery; to John Mackenzie, for his paper on Bechuanaland and Austral Africa; to Edward Combes, C.M.G., for his paper on the industries and commerce of New South Wales; to G. Gordon Hake, for his paper on Cyprus since the British occupation; to Prof. W. N. Hartley, F.R.S., for his paper on photography and the spectroscope in their application to chemical analysis; to Prof. R. Meldola, for his paper on the scientific development of the coal-tar colour industry; to B. H. Baden Powell, C.I.E., for his paper on Indian manufactures from a practical point of view; to Capt. Richard Carnac Temple, for his paper on the every-day life of Indian women. Thanks were voted to the following members of the Council for the papers read by them:—To Capt. Douglas Galton, D.C.L., C.B., F.R.S., for his paper on results of experiments on mechanical motors for tramways made by the Commission at the Antwerp Exhibition; to W. H. Preece, F.R.S., for his paper on domestic electric lighting.

FOREIGN TELEGRAMS.—On and from the 1st prox. the new regulations respecting foreign telegrams agreed upon at the International Telegraph Conference held at Berlin will come into force. The principal alterations are the following:—(*a*) The rules relating to European have been assimilated to those relating to extra-European code telegrams, the limit of length of a word in such messages being fixed at ten letters, and words drawn from more than one of the authorised languages, viz., English, French, German, Italian, Dutch, Portuguese, Spanish, and Latin being allowed; (*b*) the names of both the office and the country of destination will be counted in the address as one word each, whatever their length, provided they are written as single words by the sender, and are spelt in accordance with the official list; (*c*) the sender of a telegram will be able to have it repeated from office to office during transmission by paying an additional quarter-rate instead of a half-rate as at present; (*d*) if the sender of a European telegram prepays a reply, and the reply form is not used by the addressee, the amount prepaid for a reply will not be refunded as hitherto; (*e*) if the addressee of a telegram has it repeated and it then proves that only a portion of the telegram was inaccurately transmitted, only a proportionate part of the charge will be refunded; (*f*) the charge for any word or words omitted during the transmission of an extra-European telegram will be refunded; (*g*) the rates to several countries will be reduced, as may be seen on reference to the "Post Office Guide" for July. The following are a few examples:—Russia, from 9d. to 6½d.; Spain, from 6d. to 4½d.; Italy, from 5d. to 4½d.; India, from 4s. 7d. to 4s.

ATMOSPHERIC ELECTRICITY.—The following is an abstract of a paper by Prof. Franz Exner in the *Philosophical Magazine*. It says:—"After a critical historical discussion of previous theories, the author communicates the results of his experiments on this subject, which have extended over several years. They refer chiefly to an examination of the electrical field of the earth under *normal* atmospheric conditions. It has appeared that the equipotential surfaces are continually as if the earth had a negative charge. Over a plane the fall of potential is always linear, and its absolute value is constant if the condition of the atmosphere does not change. Such changes are due to the greater or less quantity of aqueous vapour in the air, for this leaves the earth charged with negative electricity. The greatest fall of potential amounts to 600 volts per metre in the complete absence of aqueous vapour, and sinks to below 100 volts in the height of summer. These numbers hold, however, only for continuous fine weather. A measurement of the fall of potential in summer at great heights, by means of air-balloons, has proved that this increases considerably with the height; that is, that aqueous vapour in air is really negative. All the phenomena of negative electricity are completely explained on the assumption already made by Peltier that the earth contains a negative charge. Starting from Franklin's theory, this charge appears as a necessary consequence of the gradual formation of the earth, and would correspond to an excess of electricity above the normal amount. Bodies which are in the condition last named would thus appear negatively electrified. From the magnitude of the fall of potential at the surface of the earth, the absolute potential of the earth may be determined. This is found to be $= -4 \cdot 10^9$ volt; that is to say, a point in space which is infinitely distant from all electrical masses has a potential which is $4 \cdot 10^9$ volts higher than that of the earth. The repulsive force which is exerted by the charge of the earth on a square centimetre of surface is equal to $16 \cdot 10^{-9}$ grams, and is thus extremely small.

ELECTRIC LIGHT IN PARIS.—The administration of the Opera Theatre have come to a decision which is the best testimony that they could give to the efficiency of the Edison incandescent lamp. After putting to the test, during a period of about four months, the electric light in the auditorium, the lobbies, and the grand staircase, and having thoroughly satisfied themselves as to the quality of the light, they have made a contract with the Edison Company for lighting the

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entire building with electricity. The new installation, which in size will be double that already in operation, will increase the number of lamps in the opera to 6,126, of which 5,018 will be of 10 candle-power, and 1,108 of 16 candle-power. These lamps will replace 7,570 jets of gas, and will be distributed as follows :—

Offices	1,160	of 10 c.-p. and	40	of 16 c.-p.
Stage	1,568	„	120	„
Auditorium and pavilion	1,212	„	306	„
Lobbies and staircase	1,010	„	642	„
Cellars	68	„	—	
	5,018	of 10 and	1,108	of 16.

Gas will thus be entirely done away with, and the whole of the opera house will be lighted by incandescent safety lamps, of the kind required by the Prefecture of Police. This step is the more important as it has been taken conjointly by the State and the directorate of the theatre. The contract entered into with the Edison Company is made for a period of ten years. The light will be furnished by the company for a sum equal to the average outlay for gas during the last ten years. Supplementary lighting, such as that for balls, rehearsals, &c., will, of course, be paid for extra. In the face of such a triumph for the electric light, it is beyond question that we are fast approaching the time when all places of amusement in the French capital will be illuminated by electricity. As we pointed out last week, the subject is engrossing the attention of the directors of many of these establishments, for they are beginning to perceive that gas as an illuminant has had its day.

Germanium.—M. Lecoq de Boisbandrin, when he discovered a new metal some years ago, gave it the significant name of gallium. We have recently become indebted, says the *Revue Industrielle*, to the Germans for germanium. This substance has been found in an argentiferous mineral, met with in the mine of Himmelfuerst, near Freiberg. This mineral was called argyrodite by Prof. A. Weisbach on account of its appearance, and was examined at the blow-pipe by M. T. Richter, who showed that it consisted principally of silver and sulphur together with a small quantity of mercury. More complete analyses fixed the proportion of silver at 73 to 75 per cent., that of sulphur at 17 to 18, with 0·21 per cent. of mercury, a little iron, and some traces of arsenic. But about 6 or 7 per cent. always escaped the ordinary methods of qualitative analysis. This was something to excite the curiosity of a chemist, and although the research was rather tedious, M. C. Winkler set to work to determine the exact composition of this rock. He was thus led to establish the existence of a new element, much resembling antimony, but still very distinct. This was germanium, which is distinguished by the following reactions: Argyrodite heated out of contact with air, preferably in a current of hydrogen, gives a black, crystalline, very volatile sublimate, capable of being melted into drops of reddish brown, and principally composed of sulphide of mercury and germanium. The sulphide of germanium is a sulphacid, easily soluble in sulphydrate of ammonia, and giving when precipitated by pure hydrochloric acid a snow-white powder, which is immediately dissolved by ammonia. In the presence of antimony or arsenic the precipitate is always more or less tinted with yellow. Heated in a current of air or in nitric acid the sulphide of germanium is converted into a white oxide, which does not volatilise even at a red heat. It dissolves in caustic potash, and the alkaline solution, when treated with sulphurretted hydrogen, reproduces the white precipitate, more or less quickly according to the degree of concentration of the liquid. The oxide, like the sulphide, is reduced by hydrogen, and yields a grey substance, slightly lustrous like arsenic, volatilisable at a white-red heat, but less easily than antimony. In this operation it sublimes on the glass walls in crystals which have the appearance of sublimated iodine, without any indication of fusing, and cannot be taken for antimony. With a current of gaseous chlorine a white chloride is obtained more readily volatilised than the chloride of antimony. Dissolved in water and treated with sulphuretted hydrogen the white precipitate is reproduced. From the whole of these facts the existence of germanium seems to have been determined. There still remains to fix its atomic weight with a certain amount of exactness, in order to know whether it ought to take the place reserved by the theory of Mendéléeff between antimony and bismuth.

Polarisation of Lead.—A preliminary series of experiments by F. Streintz and E. Aulinger was made by Fuchs's method to determine what share the hydrogen evolved at the negative electrode has in the value of the polarisation. The lead plates were in a vessel containing a 10 per cent. solution of sulphuric acid, and were charged from a battery of three Daniell cells; by means of a capillary syphon tube this vessel communicated with a second one in which was a zinc plate in concentrated solution of sulphate of zinc. The lead plate at which the hydrogen was evolved was in connection with one pair of quadrants of an Edelmann's electrometer, and with earth, the zinc plate being connected to the second pair of quadrants. The standard of comparison was a Latimer Clark cell giving 1·433 volt at 15·5° C. Half an hour after closing the circuit of the charging battery, the difference of potential Zn | Pb + H was − 0·26 volt, which rose to 0·29 volt in an hour, and became 0 45 volt on opening the circuit of the charging battery. This last value was maintained for some time, and it was only after several hours that it reached 0·75 volt, the difference previously found for Zn | Pb. This behaviour of the lead plate may be explained by the assumption that it is only so long as nascent hydrogen is evolved that it causes a polarisation, and when the evolution of gas ceases the polarisation ceases. A different mode of operating was then adopted, by means of which the potential of either lead plate could be compared with that of a zinc plate in sulphate of zinc by means of an electrometer, at the same time that the discharge current was measured on a galvanometer. From the tables of results it is apparent that the E.M.F. almost immediately attains a value which approximates to that between metallically clean lead and zinc. The difference of potential between the zinc and the lead plate at which hydrogen is evolved increases slowly during the first three minutes that they are connected to the electrometer, and rapidly during the fourth minute, soon after which there is a sudden jump to a much higher value, which afterwards only increases very slowly. The value of the current meantime decreases proportionately to the increase of the E.M.F. The behaviour of the plate covered with peroxide is very different; at the very beginning its potential, compared with zinc, is very much higher than that of the other plate, and only diminishes by about $\frac{1}{10}$th volt in the first half minute, after which it remains practically unaltered. From the experiments it may be concluded that just as the lead plate covered with peroxide is the carrier of the chief E.M.F., so the plate covered with hydrogen is the source of its falling off. The discharge of the couple is not due to the de-oxidation of the peroxide plate, but to the oxidation of the metallic plate. Whilst, therefore, the hydrogen evolved on the depolarisation does not suffice to reduce the whole of the peroxide of the one plate, the oxygen evolved is sufficient to cover the metallic plate with a layer of oxide, or even of peroxide.—*Jour. Soc. Tel. Eng.*

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THERMO-ELECTRICITY.—Although many combinations of conductors producing a greater or less E.M.F. under the influence of heat have already been described, the search for bodies which possess this property has acquired a great interest on account of their possible application to thermo-electric generators. M. G. Chaperon has, according to the *Revue Industrielle*, methodically studied from this point of view a certain number of chemical compounds, chiefly chosen amongst those which can be easily reproduced in their active state. The method employed in this research is characterised by being applicable to fragments of any form whatever, and, if need be, of very small dimensions. It consists in applying two points of one of these fragments to two metallic walls, which conduct heat well, whose temperatures are evaluated as closely as possible, and which serve as electrodes to show and measure the E.M.F. of the couple thus formed. One of these walls is that of a thin silver tube traversed by a current of water at the temperature of the surrounding air, and forming part of a pair of pincers with which the body under consideration is held. By means of these pincers a second point of the body is applied against a hot wall, that of an iron crucible full of fusible alloy, and into which a thermometer is plunged. Contact ought to be insured by a constant pressure. The procedure is then to measure during slow variations of temperature a series of values of the difference of potential of the two plates. The iron crucible is united to the electrical measuring apparatus by a silver wire sufficiently long for its extremity to remain cold. The E.M.F. measured is then, in virtue of the law of successive contacts, that of the couple formed by the body which is under investigation and silver. For certain compounds capable of attacking iron a thin leaf of silver is also interposed at their point of contact with the crucible. For more elevated temperatures another arrangement has also been employed, in which the hot contact is taken at a point of a silvered copper bar heated at one extremity. The temperature is evaluated at another point of the same section of this bar with a second body already studied, and which thus serves as thermometer. In the various couples thus formed the contacts of active substances with the electrodes ought to take place by small surfaces, which are as distant from one another as possible, in order that the temperatures of these contacts may be as nearly as possible those of the electrodes, which alone can be estimated. One thus obtains with substances in general bad conductors elements of an enormous resistance; therefore the rapid measurement of the E.M.F.'s is only rendered practically possible by the use of Lippmann's electrometer. Besides, this only serves to show the equilibrium of the force measured with that given by a potentiometer with wire of a reduced form giving $\frac{1}{5000}$th of a volt. It is possible with this conjoint apparatus to obtain sufficiently easily curves representing the law of variation of the E.M.F.'s as functions of the fall of temperature. M. G. Chaperon then quotes some examples of measures thus made on substances little studied and enumerated below. Positive bodies: iodide of silver, phosphide of zinc, sulphide of tin, crystallised galena, oxide of copper in a very thin plate, arsenide of zinc. Negative bodies: sulphide of silver, specular iron, crystallised galena. The curves representing the force as a function of the fall of temperature indicate in general a uniform increase starting from a certain point; they have been followed up to 250 or 300 degrees. Nevertheless, for the iodide, and, above all, for the sulphide of silver, the law of variation undergoes a sudden change, and hardly appears susceptible of being represented by a continuous function.

TELEPHONIC STATISTICS.—The following is a continuation from our last issue of M. Rothen's telephonic statistics:—

The Argentine Republic.

Towns.	No. of Subscribers.	Population	Population per Subscriber.	Subscription in Francs.
Buenos Ayres...	1,544	340,000	220	450

This information is brought up to 18th October, 1885. The exchange is worked by the River Plate Telephone and Electric Light Company.

Uruguay.

Montevideo	389	111,500	287	240

This information is brought up to 18th October, 1885. The exchange is worked by the River Plate Telephone and Electric Light Company.

The Sandwich Islands.

Honolulu	425	14,114	33	—
Other towns ...	600	—	—	—

The exchanges are worked by the Havaian Telephone Company.

India and Ceylon.

Calcutta (*a*)	336	794,645	2,365	710
Bombay (*b*)	281	645,000	2,295	710
Rangoon (*c*)	109	97,000	906	710
Maurice (*c*)	76	64,000	842	—
Singapore (*c*) ...	65	97,000	1,492	600
Colombo (*c*)	63	100,000	1,587	—
Madras (*c*)	43	397,500	9,244	710
Moulmein (*c*) ...	15	54,568	3,638	—
Kurrachee (*b*) ...	14	48,000	3,429	—

This information is brought up to the 13th October, 1885. The companies working the different exchanges are:—(*a*) Bengal Telephone Company; (*b*) Bombay Telephone Company; (*c*) Oriental Telephone Company.

China.

Shanghai	139	300,000	2,158	208

This information is up to the 13th October, 1885. The exchange is worked by the China and Pacific Telephone Company.

Egypt.

Alexandria	434	166,000	382	—
Cairo	218	498,000	2,284	—

This information is brought up to 13th October, 1885. The exchanges are worked by the Telephone Company of Egypt.

Queensland.

Brisbane	287	28,000	98	—
Maryborough ...	57	8,608	151	—
Townsville	51	3,000	59	—
Rockhampton ...	45	7,431	165	—

Mid-Australia.

Adelaide	529	27,300	52	—
Port Adelaide ...	46	2,481	54	—

This information is brought up to the month of May, 1884. The telephone exchanges are worked by the Government. The total length of the wires of the two exchanges is 1,572 kilometres. The subscription is 300fr. for a maximum distance of 800 metres, additional distances being paid for at the rate of 32fr. 50c. per 400 metres. For the right to converse between Adelaide and Port Adelaide subscribers pay an additional annual charge of 250fr. The transmission and receipt of telegrams are charged at the additional rate of 30 centimes per despatch. The service is permanent at Aelaide.

New South Wales.

Sydney	260	224,211	862	—

This information is brought up to the month of May, 1884. The exchange belongs to the Government. The subscriber pays for his line and its appointments, and in addition an annual subscription of 125fr. for a distance of 1,600 metres. Every additional 400 metres pays a supplementary charge of 32fr. 50 centimes.

Victoria.

Melbourne	716	282,947	395	—
Ballarat	81	35,586	439	—
Sandhurst	37	28,167	761	—

This information is brought up to May, 1884. The exchanges are worked by the Melbourne and Colonial Telephone Exchange Company, but the Government also establish some private communications.

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EARTH CONDUCTION.

BY A. J. S. ADAMS.

The future prospects of telephony and practical telegraphy would seem to be somewhat in the dark; but it is nevertheless unwise to discount the possibilities of such systems until we are possessed of a more exhaustive knowledge of the physical forces that are brought into play. Each successive step in elimination and elucidation is found to advance the general subject; and remembering how little is really known regarding some phenomena connected with electricity and magnetism, the surprise is that so much has been accomplished, and that there exists to-day such solid ground for congratulation and encouragement.

Our want of knowledge in respect to the telephone may be instanced by the several theories that have been advanced to explain the precise action of the telephone, and the remaining fact that no theory has yet proved to be incontrovertible, or to greatly modify our earlier conceptions. In respect to line conduction, our imperfect knowledge has been rendered conspicuous by the recent labours of Prof. Hughes, and by the experiments of Mr. W. H. Preece, and there is in connection with this point much yet to be learned. It is possible, however, to go farther, and show that our need of information obtains not only in respect to the apparatus and to the line, but also in relation to the earth—where the earth's crust forms part of the circuit—and that the earth then exerts no inconsiderable effect upon the general result. In connection with this point it will be admitted that a telephone circuit, of which the earth forms a part, is never so satisfactory as it is where the circuit is wholly metallic, a feature clearly indicated in the interesting paper lately contributed to the Society of Telegraph-Engineers and Electricians by Mr. Preece, although it must be confessed the difference remains unexplained. Again, as regards the question of earth conduction, it may be remembered that in 1875 Mr. James Graves, of Valentia, contributed to the society already referred to an important communication upon "variations due to earth-plates," and detailed the extraordinary difficulties that were experienced by him in reading from the mirrors attached to the Atlantic cables, by reason of variations and disturbances which produced a constantly irregular motion of the "spot."

A brief consideration of this phenomenon may not be out of place at the present time, and possibly it may be gathered from the results of some experiments that have been made that the disturbance complained of by Mr. Graves possesses a marked and distinctive character, and, first, as to the probable resistance introduced into a circuit by the earth's crust. The earth cannot be considered as a conductor of electricity, apart from the moisture held by it; it is evident, indeed, that the earth's capacity for conduction will be to a large extent proportional to the moisture so held. When, however, the wide expanse of moist earth that almost necessarily divides two earth-plates is considered, it is difficult to apprehend any appreciable resistance to exist between them; and yet that some resistance is offered by the earth will appear from the following experiments:—Two clean copper plates, about 18in. square, were buried 20ft. apart to a depth of 4ft. in a soil of loam, overlying sandy gravel. The earth plate electrolysis current steadily fell from first maximum to a point at which it was very weak, and then remained constant. Across and midway between the two plates shallow trenches were dug, and were kept supplied with water for some hours, the ultimate result being that, by reason apparently of the diffusion of moisture and the reduction of resistance, the current force increased several degrees.

The apparatus used was a sensitive Thomson reflecting galvanometer of 700 ohms resistance, and the scale was twenty-seven feet distant from the galvanometer, so that a very slight variation of force in the galvanometer would be well represented by the movements of the "spot." In the further experiment two flat coils of No. 18 copper wire were buried upright about 18in. below the surface, and 4ft. apart. The electrolysis current at first equalled a deflection of 38in. upon the scale, but after falling steadily came to a stand at 18in. from zero, and remained constant. The ground over and around these upright coils was now thoroughly soaked with water, and two days were allowed for diffusion. A trench was then dug of the same dimensions either way as the coils, between and parallel to them; the trench was a foot wide at top and tapered at the bottom. The effect of this trench was to decrease the deflection by 8in. A small piece of dry board was ledged across the trench at its centre, and a child was instructed to build a bridge or road of damp earth from side to side over the board. The instant contact was made by the damp earth across the board, the deflection went up with a bound, and every succeeding reduction of resistance by the addition of earth to the bridge was clearly visible in the movement of the "spot." By this bridge the deflection was permanently increased by three inches, but again fell off as the earthen bridge dried under the sun. The effect of filling in the trench was also rendered clearly apparent by the swinging of the "spot" and ultimate increase.

It would thus seem that the earth's crust presents a higher resistance to the passage of electricity than would at first sight appear; secondly, and perhaps of greater moment, as to the apparent variability of the earth's conduction. Reference has been made to difficulties experienced at Valentia in reading the mirror signals received from America, by reason of irregular variations of the "spot," and which seemed to emanate from the earth plate. In that instance the disturbances could not be eliminated until *earth* was virtually made by means of the sheathing of the Atlantic cables, instead of by the ordinary earth plate method. It may be stated that precisely similar variations are to be observed upon any circuit of which the earth's crust forms a part, provided that the means of observation are sufficiently sensitive, and that the wire tested is free from the larger effects of leakage, induction, and earth current.

Perhaps the most natural explanation that suggests itself concerning these variations is that of earth-plate variation—*i.e.*, a variation of the actual force generated at the plates, or of their resistance. In order to investigate the phenomenon from that point of view, the sensitive Thomson reflecting galvanometer was brought into use, and tests were made of a great number of combinations—simple and involved, new cells and old, pairs of similar and dissimilar metals—without once obtaining the slightest sign of the variation in question. In every case there was the usual electrolysis current, which steadily fell from a first deflection to a stationary minimum, and which by disconnecting the circuit, or by inserting heavy resistance, would temporarily increase; but nothing beyond that was noticeable. It was thought that in the case of an earth plate the deposited hydrogen might by some means be disturbed, and so vary the resultant force. To test this point the following experiment was made:—The ends of two clean copper wires were immersed in a jar of sand and water; in the centre of this cell was inserted a 1¼in. glass tube, 3ft. high, so that by keeping the tube filled with water there would be a circulation of the liquid up through the sand and around the wires, the idea being to effect a disturbance of hydrogen. No visible effect was produced, however, and it seemed clear the variation in point was not of simple earth-plate causation.

Another possible explanation of these variations suggested itself, namely, that the influence of slight earth currents upon the earth plates might produce an intermittent and changing state of polarisation. In order to investigate this point a No. 18 copper wire was erected and perfectly insulated, and extended from my house to a distance of 300 yards upon one side, and of 170 yards upon the other. The distant ends were terminated by means of large coils of the same wire, buried to a depth of about 6ft. In my own garden similar *earths* were put in for us as might be required. With the Thomson reflecting galvanometer in circuit, whether upon the whole length of line, or upon the right or left sections, it was always necessary to shunt down the electrolysis current in order to bring the "spot" within the ten foot scale, and notwithstanding this reduction of current passing through the galvanometer coils, the variations under consideration were always present. This variation, this *constant* movement of the spot, was usually much greater in amplitude

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upon the 300 yards length than upon the 170 yards section. Why it was difficult to trace, but it may be added that a baker's oven, which was heated each day, lay directly in the line of the two *earths* of that section. Then, also, the amplitude of the variation altered very considerably one day with another, sometimes the swing of the "spot" being so much as eight feet from side to side, *i.e.*, four feet each side the zero. It was difficult to decide how the question of earth current causation should be attacked; the first experiment, however, afforded no trace of concurrency in the variations of the two sections of wire.

A further experiment was conducted with a view to question the effect of earth-current *directive* force upon the earth plates, and was arranged thus:—A circle 40ft. in diameter was described, and the chief points of the compass carefully staked upon it. Two poles were sheathed with clean copper at their lower extremity, the copper being connected to the experimenting room by means of loose-covered wires. The sheathed ends of the poles were driven into the moist earth to a depth of two feet. Starting with the poles at opposite points —N and S—upon the circle a careful observation was made, and the slight but clearly discernible oscillations of the "spot" were noted. Similar observations were repeatedly made with the poles at each pair of opposite points, but without leading to any trace of directive effect, both variation and amplitude being pretty much the same all round the circle, and the idea of earth-current connection was, for the time being, given up. The fact had, however, been elicited that these variations were in a slight degree obtainable from *earths* that were comparatively near one another, although when very near the effect upon the apparatus ceased. Prior to dismantling the arrangement the following experiment was tried:—Two pairs of earth plates were buried thirty feet apart, the respective plates of each pair being three feet apart. Upon joining either pair through the galvanometer no variation effect was observable, but when either plate of one pair was joined through the galvanometer to either plate of the other pair slight oscillations of the spot became apparent, indicating, it would seem, that at least some extent of the earth crust between a pair of earth plates is necessary in order to obtain these effects.

The remarks submitted here are not intended as a solution of this phenomenon, for it will be apparent that many important experiments await trial; but it is thought that the importance of the subject in its relation to long-distance telephony, and to the more sensitive systems of telegraphy, is such as to deserve a larger share of attention than it has hitherto received, and, further, that these results, which seem to point to a variation in the conducting power of the earth itself—locally, perhaps—warrant a more thorough and continued course of investigation than is within my own reach. It would be of interest also to know if and how far this variation is related to the sound disturbances heard from a buried microphone.

INDUCTION IN CONDUCTORS.*

The law of Ohm is only true when the current has become constant. In the greater number of cases we have to consider variable currents. Dynamo machines, whose usage is so widespread, furnish currents essentially variable. The variations are evident in machines with alternate currents. They are less so in machines, improperly called of constant currents, in which the telephone, nevertheless, reveals rapid changes of intensity. Those who have a telephonic wire near a wire traversed by currents called continuous, may soon disagreeably perceive that these currents do not merit their reputation. It is a curious thing that the currents of alternating machines, in which the variations of intensity are slower than in other machines, have a less hurtful influence on the telephone. They give a deep hum, which does not mask the sound of the voice like the sharp crackling given by machines with continuous currents.

Batteries and accumulators are capable of giving permanent currents, on the condition that their circuit has been closed sufficiently long.

Let us consider, not otherwise, a circuit formed by a battery, a subterranean line, and the earth.

At the moment of closing the circuit the cable charges itself, and during the whole duration of this phenomenon the current varies. It does not attain the stable state till after a shorter or longer time (several seconds in Atlantic cables). It is only after this delay that the law of Ohm is applicable to the calculation of the intensity of the current.

The amount of the charge is extremely small on aerial lines, and it may be neglected on short ones.

Consider, now, another class of phenomena. Suppose that a telegraphic line is parallel to a telephonic line. At the moment of making the telegraphic circuit, an inverse induction current traverses the telephonic circuit, and a direct one when the telegraphic circuit is broken. The induced current depends on the coefficient of mutual induction between the two wires. If l is the length along which the two wires are parallel, h their distance apart, this coefficient is approximately expressed by

$$M = 2l\left\{\log\left(\frac{2l}{h}\right) - 1\right\}$$

The phenomenon of induction arises also in the circuit itself where the current forms, and then it is called self-induction. Let us consider the case where a current arises in a coil of wire. At the moment of closing the circuit the coils react on one another, and an electromotive force of induction is produced, which tends to weaken the inducing current. Similarly, when the circuit is broken we have a direct induced or "extra" current. The self-induction of a current depends on the form of the circuit, and practically the current usually reaches its full strength in a very short time indeed. Nevertheless in telegraphic systems, where they employ very rapid mechanical keys, the currents may not reach the permanent state.

Let us take the case where the E.M.F., instead of being constant like that of a battery, varies in accordance with a given law. This is the case of a machine with alternating currents, where the E.M.F. may be expressed at each instant by

$$E = E_0 \sin\frac{2\pi t}{T}$$

Such an equation is represented graphically by a sinusoide, the abscissæ denoting time and ordinates the corresponding values of E. E_0 is the maximum value of E, T the space of time which elapses between two like indulations of the curve.

The E.M.F. which produces telephonic currents may be defined by an analogous law of variation; but, while the values of T vary between $\frac{1}{80}$th and $\frac{1}{120}$th of a second for ordinary alternating machines, they vary between $\frac{1}{300}$th and $\frac{1}{2000}$th of a second for telephones.

If there was no self-induction in the circuit where the periodic E.M.F. acts, the intensity of the current would be expressed by

$$i = \frac{E}{R} = \frac{E_0}{R}\sin\frac{2\pi t}{T}$$

The phases of the current would coincide with those of the E.M.F.

In the case where the circuit has a co-efficient of self-induction L, the intensity at each instant is

$$i = \frac{E_0}{\sqrt{R^2 + \frac{4\pi^2 L^2}{T^2}}}\sin\left(\frac{2\pi t}{T} - \phi\right)$$

where ϕ is given by the equation $\tan 2\pi\phi = \frac{2\pi L}{T}$.

The effect of the phenomenon of self-induction is to produce a retardation in the undulations of the current and to diminish the intensity as if the resistance had increased in the ratio of $\sqrt{R^2 + \frac{4\pi^2 L^2}{T^2}}$ to R.

The quantity under the root sign represents the apparent resistance of the circuit, and this may become much greater than the actual resistance.

* From a paper by Prof. Eric Gerard, in the *Bulletin de la Societe Belge des Electriciens*.

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Let us suppose, for example, that a telephonic current, whose period is $\frac{1}{1000}$, traverses a coil, whose resistance is 50 ohms, and whose coefficient of self-induction is 0·6. Then the value of $\sqrt{R^2 \tau \frac{4\pi^2 L^2}{T^2}}$ is about 4,000, or 80 times the resistance of the coil.

It has been long known that the phenomena of self-induction are not well marked, except in conductors rolled up in the form of coils. Nevertheless experiment has shown that a rectilinear wire sufficiently long may become the seat of an extra current capable of producing a spark. Kirchhoff and F. Weber have given expressions for the coefficient of self-induction in rectilinear wires; but this phenomenon was little studied till the recent experiments of Prof. Hughes have drawn the attention of electricians to it.

Let us consider a rectilinear conductor of circular cross-section in which a current originates. This may be resolved into an infinite number of infinitely small currents passing parallel along the wire. All these small elementary currents react one upon another so as to give rise to an inductive E.M.F. contrary to that which produces the current. The coefficient of induction in the case of two rectilinear parallel currents is as we have seen

$$2l\left\{\log\left(\frac{2l}{h}\right)-1\right\}$$

Now, the mean distance of all the elementary currents traversing a circular section of radius r is

$$h = 0{\cdot}7788r,$$

whence we conclude that the coefficient of self-induction of a like conductor is

$$L = 2l\left\{\log\left(\frac{2l}{r}\right)-0{\cdot}75\right\} \quad \ldots \quad (1)$$

The phenomenon of self-induction is much more marked in a magnetic conductor, such as an iron or steel wire. Every time that a current arises in the wire the exterior layers of the conductor are magnetised in a direction perpendicular to that of the current, whence there results a circular magnetisation. This magnetisation absorbs a part of the energy of the current and weakens it. When the current ceases, the magnetisation disappears and the energy reappears under the form of extra-current.

The coefficient of self-induction of a magnetic wire contains a constant depending on the magnetisability

$$L = 2l\left\{\log\left(\frac{2l}{r}\right)-0{\cdot}75+k\right\} \quad \ldots \quad (2)$$

Telegraph engineers had long remarked that copper conductors are more favourable than iron conductors with apparatus for rapid transmission.

The importance of this observation has been placed in a clear light in consequence of the experiments of Prof. Hughes.

These experiments and their results are well known. They have been criticised by Prof. F. Weber and others, who have concluded that the differences observed by Hughes in the case of non-magnetic bodies arose from particular conditions of the experiments.

For our part, we have studied a method which is more easily discussed than that of Prof. Hughes, and of which the following is a description.

The conductors to be compared, M N and M′ N′ (Fig. 1), form a circuit with a battery P, an interrupting wheel R, and a rectangular movable frame covered with wire. The auxiliary wires $f_1 f_2$ and $f_1' f_2'$, situated in a plane normal to that of the principal circuit, may be united either to the two coils G_1 and G_2 of a differential galvanometer, or to some coils T_1 and T_2, belonging to a differential telephonic arrangement. A revolution of the commutators enables the transposition to be made rapidly.

Suppose that communication is established with the differential galvanometer, and that the principal circuit is traversed by a permanent current. The galvanometer needle will deviate as long as the resistance $a\,b$, contained between the auxiliary wires $f_1 f_2$, is not equal to $a'\,b'$, the points of junction of the wires $f_1' f_2'$.

The positions of the riders must be regulated to satisfy the conditions of equilibrium. If we call each of the two equal resistances r, I the intensity of current, the difference of potential between the points $a\,b$, or $a'\,b'$, will be $E = Ir$.

Next let us unite the auxiliary wires to $T_1\,T_2$, and let us set the interrupting wheel in motion, so as to produce intermittent currents in the principal circuit. T_1 and T_2 are as nearly alike as possible in all respects, and the variable currents which branch into the two coils T_1 and T_2 act in opposite senses on a third coil T_3 united to a telephone.

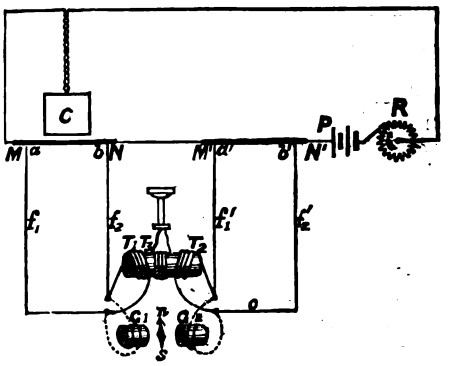

FIG. 1.

One commences by regulating the position of this coil T_3, so that the telephone gives no sound when $f_1 f_1'$ and $f_2 f_2'$ are united to the same two points of the principal circuit—that is to say, when the extremities of the coils $T_1\,T_2$ remain constantly at the same difference of potential.

This being the case, the difference of potential between a' and b' is at any instant

$$e = ri + L\frac{di}{dt}$$

L being the coefficient of self-induction of the section $a'\,b'$.

The difference of potential between the points $a\,b$ is

$$e' = ri + L'\frac{di}{dt} + M\frac{di}{dt}$$

L′ is the coefficient of self-induction of $a\,b$, M is the coefficient of mutual induction between the frame C and the conductor $a\,b$. The position of the frame C is regulated by bringing it closer to, or moving it farther from, the conductor $a\,b$, till the telephone gives no sound, which happens when M equals the difference of L and L′. When this is the case, the E.M.F.'s in $a\,b$ and $a'\,b'$ are always equal; then we have $e = e'$, whence

$$L = L' + M$$

Now M may be easily calculated. If the sides of C are equal and sufficiently small relatively to $a\,b$

$$M = 2\,a\,n\,l\,\frac{a+h}{h}$$

a being the side of the frame, h the distance of the frame from $a\,b$, and n the number of coils in C.

On the other hand, L and L′ may be calculated by the formulæ (1) and (2).

The method furnishes, then, a means of verification of these formulæ.

It is to be observed that the telephone is necessary to observe the variations of the E.M.F. e. If one left the differential galvanometer in communication with the auxiliary wires, the needle on account of its inertia would have obeyed the mean currents traversing the coils. Now, since the integral of the induced currents produced in the successive variable periods is nul, it follows that the mean current would have remained the same in the two branches of the galvanometer. This method has been used for iron, soft steel, copper, phosphorus, bronze, and brass wires. The conductor, for comparison, was a tube of mercury. The results of the experiments on the above non-magnetic metals satisfy sensibly the equation (1). For iron and soft steel the results are in accordance with equation (2), in which k varies from 25 to 30.

We carried the verification further, and took the case of long copper wires, substituting for the inductor C, and for

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the conductor M N two coils of variable induction. The results again verified the calculation.

We have as yet only studied conductors with circular section (and these are most used in practice).

Hughes has shown that conductors, with rectangular section, have a more feeble coefficient of self-induction than round conductors.

Unhappily conducting bands are little applicable to aerial lines; wind and snow would soon make havoc among such conductors.

Metallic bands have been employed for a long time for the rods of lightning conductors, in consequence of experiments made by Guillemin. This physicist explained the greater conductivity of bands for electric discharges by supposing that the fluid passed off by the surfaces of the conductors. It is seen that the phenomena of self induction give a better account of the observed differences.

Conductors formed by metallic cords act differently according as the metal is magnetic or non-magnetic.

In the first case, the induction is much less than in a conductor of the same circular section. In fact, the circular magnetisation is constrained by the division of the section in the same manner as Foucault's currents are hindered in machines by the employment of bundles of wire. Besides the mean dispersion of the elementary currents is increased. In cords of non-magnetic bodies the differences observed are much less, and they depend solely on the greater dispersion of the elementary currents.

The considerations which we have just presented are of the greatest importance from a practical standpoint. They explain facts which formerly appeared obscure or ill-defined, and they lead to new rules on the establishment of electric lines.

It has been remarked in the United States that the compound wire formed of steel coated with copper is preferable to iron wire of the same conductivity. In such a wire a part of the current passes in the steel core and the other in the copper envelope. These two parallel currents tend to magnetise inversely the exterior layers af the steel core. This differential action diminishes considerably the coefficient of induction of the conductor.

For the construction of lightning conductors, circular iron rods are inferior to cords of the same metal, or to bands of copper.

Conductors of copper or bronze are specially preferable for the transmission of variable currents. The currents on both telephonic and nearly all telegraphic lines are variable, because, thanks to M. Van Rysselburghe's process, telegraphic lines serve also for telephonic communication. Soft copper cannot be employed on aerial lines on account of its feeble mechanical resistance; but it may be replaced by compounds known under the name of bronze.

It will be seen that practice has got the start of theory in the choice of telephonic conductors, and the promoters of the telephone in Belgium ought to be praised for having adopted from the first conductors with a copper base.

A SECONDARY BATTERY OF TWENTY-FIVE YEARS AGO.

During the discussion of Mr. Bauer's paper, read before the American Institute of Electrical Engineers, on "Secondary Batteries for Lighting and Power," reference was made to the work of an early inventor, to whom also Mr. C. J. Kintner referred in his lecture before the Franklin Institute.

Inquiry having been made on the subject, we may say that this inventor, Charles Kirchhof, in a patent granted to him February 26th, 1861, describes a form of storage battery to which many inventors of the present day are referred by the examiners in the Patent Office, and it may therefore prove of interest to our readers to learn of the work of a man who was so far in advance of his time and who came so near the solution of the problem of the practical application of the storage battery.

The patent referred to shows that Kirchhof possessed an intimate knowledge of the previous work in this field, and proves also that he himself must have studied the subject very deeply. After referring to Ritter's charging pile, Grove's gas battery, Poggendorff's polarisation apparatus, to Faraday, Mendler, and others, he enters into the theory of the storage battery, and then shows the new form of battery devised by himself. We quote from his description :—

"A small and powerful regenerator is the following :—A glass (see Fig. 1), A, is closed by a cover of lead, B, to which electrodes of platina-foil, C C, are soldered, diverging from each other as they descend. Said electrodes are perforated, and I roughen them by hammering them between emery paper. They need not be platinised. A glass tube, E, inserted through a hole in the cover B, isolates the positive electrode D of platina, which is suspended in it, and nearly extends to the bottom of the glass, where it spreads and branches around, without touching, however, the other platina-foil. The glass is filled up with a solution consisting of about six parts (by weight) of nitrate of lead, two or three parts of acetate of lead, and one part of nitrate of potash, dissolved in from eight to twelve times the quantity of water. The solution is now filtered and the following added: four parts of

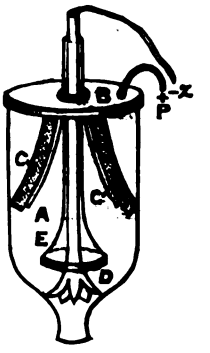

Fig. 1.—Kirchhof's Storage Battery.

acetic acid (liquid commercial at 21 per cent.), one part of nitric acid, and scarcely one-sixteenth part of nitrate or acetate of iron (or nitrate or acetate of zinc). When too much of the iron is taken, the turning of the light colour of the solution into a yellowish one will indicate it. On connecting the cover B with the positive pole P, and the isolated electrode D with the negative end Z of any generator, the foil will turn black peroxide of lead, and the positive electrode will be surrounded by crystallised lead. This is a very positive element, and the former (peroxide) the most negative known to exist, and also a good conductor.

"By changing the proportions of the substances of the solution, more or less peroxide or metal will be deposited, and the conducting power, &c., may be increased or decreased in the same ratio. If pure ingredients are employed in the preparation of the solution, it will last for a long time.

"Metals of a more negative character than the above-named lead (except quicksilver) covering the positive electrodes are often very injurious. This is not the case, however, with the more positive elements. The combination of several cups or glasses is the same as in galvanic batteries.

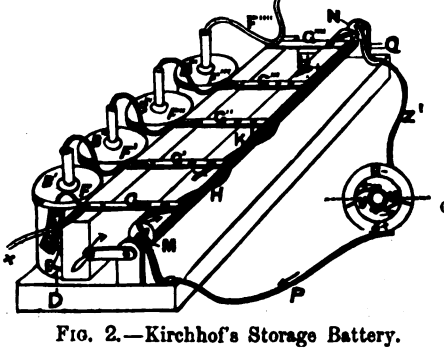

Fig. 3. Commutator.

Fig. 2.—Kirchhof's Storage Battery.

"Platina may be saved by substituting a positive electrode of lead (amalgamated with quicksilver) instead of platina.

"A more perfect apparatus is the double regenerator. Each glass of the same is provided with two pairs of electrodes, each pair acting independently of the other. One pair discharges while the other gets charged. In this manner the quantity of the elements of the solution remains the same. In some cases one positive electrode may answer at the same time for the two negative ones. All regenerators may be used for discharging quantitative currents while being charged"

The patent also describes a "translator" (Fig. 2), the object of which is to charge each battery in succession, while the others of the same circuit are discharging, Fig. 3 representing the commutator of a magneto-electric machine. The points given above are those regarding which curiosity has been aroused, and which constitute the main elements of the patent.—*Electrical World.*

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THE CABLE FIGHT CONTINUED.

The battle of rates on the Atlantic cables, begun six weeks ago, is still being carried on with such vigour and obstinacy that, judging by outward appearances, it may last another six weeks—some people say six months—longer. If the several companies concerned in this most deplorable dispute are enjoying the strife, and hoping to reap a permanent advantage by maintaining it till one or other of the combatants is exhausted, nobody has any right to interfere with them. For our part we have already expressed a strong opinion adverse to the COMMERCIAL Company, and favourable to the established Atlantic companies, whose rights it has wantonly invaded. We in no way depart from that opinion now. But there are other interests to be considered besides those of the cable companies, namely, those of the public; and it is on behalf of the public chiefly that we now again return to the subject. Not that the public feels itself in any way aggrieved by what is going on; quite the contrary. Customers of the Atlantic cable wires are having a good time of it, so they think, and probably would thank nobody for putting an end to a state of things in which they seem to be the chief gainers. But they cannot be gainers in the long run, and it is this fact which we would endeavour to impress on the public if we might hope that anything we say will reach its ears and influence its judgment.

When commenting on the conduct of the MACKAY-BENNETT Company just before the commencement of hostilities, we described the circular asking their patrons to rally round them and pay one shilling for what could be got elsewhere for sixpence as a downright absurdity. Our contemporaries endorsed this description, and the circular was met with a general volley of ridicule on our side the water. But we seem to have over-estimated the shrewdness of our American cousins, or perhaps under-estimated the astuteness of the framers of that singular document. It has been openly asserted that the COMMERCIAL Company had not played the game of competition fairly; that by offering rebates to its best customers it had been in reality accepting messages at lower than the nominal rates, and thus taking an unfair advantage of its competitors. This, it is alleged, was one of the grounds on which they decided to compel the offending company either to join them in a common pool or to face the consequences of a ruinous reduction of rates. Rejecting the friendly overtures, it was open to Messrs. MACKAY and BENNETT to have either persisted in maintaining their favourite rate of 40c. per word or gallantly reducing it to 6d., like their opponents. They did neither; they reduced it to 1s., and appealed to the philanthropy of their customers. At least, this is what they seemed to do. But our latest information points to the conclusion that in reality 1s. is only their nominal rate, half of which is to be refunded if the company succeed in wearing out the attacks of its adversaries, and re-establishing the 40c. scale. Under this pledge a fairly good business is said to be doing; at all events among its American friends, who are thus made partners in a game which it is their interest, and theirs alone, to win.

Such is, no doubt, the customer's view of the matter. He wants to prevent a return to the old rates which prevailed before the MACKAY-BENNETT cables were laid, and the only way to insure this is to keep them solvent by patronising them freely, which he can do with a good business conscience, seeing that for every shilling he spends on them he is to get sixpence back again. It is true there is an "if" in the bargain; but so there is in most speculations; and this, on the whole, does not seem a bad spec to the Yankee mind, perhaps chiefly because the cables and their owners are Yankee likewise. But meanwhile these owners are not only taking charge of the "if" above referred to, but getting possession of the shillings. The chances of the sixpences ever going back to the customers' pockets seem to us exceedingly remote. Truly it is the interest of the customers to win this battle of the rates; but the longer it lasts the more will it be to Messrs. MACKAY-BENNETT'S interest to lose. In the first place, they will have to refund nothing if—much to their regret, of course—they are obliged to cave in. And, secondly, they have nothing to lose by yielding to the pressure of their powerful rivals; at least, nothing compared with what they will lose if the contest be prolonged, and if at the end of it they may only return to a rate which, however they like it on sentimental grounds, is proved to be an unremunerative basis for practical cable business. We do not say that the COMMERCIAL people are riding for a fall; but if they are, they have prepared a nice soft place to fall upon.

The mistake the Americans have made all along is in supposing that any set of business men, whether many or few, will invest large sums of money merely for the purpose of doing the public a good turn. Even if there are such persons to be found, the public have no right to their self-sacrificing services; for the community has as little claim to be served telegraphically for nothing, or next to nothing, as it has to get its cock-tail or its bread and butter for nothing. The proprietors of the COMMERCIAL cables are very worthy people no doubt, and they wished to break up what they con-

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ceived to be an injurious monopoly. But they did not wish it to the tune of a million and a half of their own money without some expectation of being rewarded for their good intentions; for if they did they might have convinced us already by making us a present of their cables, which they do not seem at all inclined to do. When, therefore, they appeal to us for support, on the ground that they are sincerely desirous of establishing a particular cable rate merely because it is lower than the competing cable companies can afford to adopt, we suspect that we are being treated either as knaves or fools. Even if we admit, which we are unable to do, that the COMMERCIAL cables can be worked at less expense than the rest, it is obvious that two cables cannot do all the work; and it is simply monstrous to expect that the pioneer cables shall be worked at a loss because some later cables have been laid at a less cost. The only fair rate of working is that which will yield a fair profit to all alike concerned. That the COMMERCIAL people are not willing to do business on this understanding is evident from their refusal to come to a joint purse arrangement with the older companies.

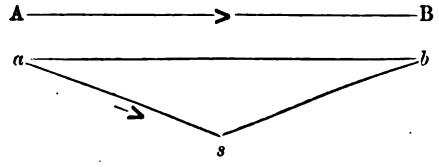
The new company ought to know its own business best, and as a mere matter of business we must let it fight its own battle; but when it comes to the public as a benefactor we take leave to dispute its pretensions. Nobody can honestly believe that it will make great sacrifices—present and contingent—for the benefit of the telegraphing public, much less that it is going to ruin itself rather than charge the public a rate which alone can pay interest on its outlay. The COMMERCIAL Company can no more be credited with disinterested motives than the enterprising storekeeper whose anxiety to give away cool drinks to senders of telegrams we report in another column. Certain members of the public may profit by it in the matter of cool drinks while the summer lasts; but, as regards the cabling public, we would remind them that they will have to pay for this battle of rates, whoever wins or loses. Rates are likely to be higher—not lower—for the temporary squabble which has reduced them to an impossible figure. Cool drinks in the shape of prospective premiums on every telegram sent at a high figure mean either deliberate fraud or reckless delusion. And a similar remark applies to those who enjoy the present advantage of low rates without any meretricious inducements thrown in. They will have to pay the piper by and bye. Meantime the companies whose rates are lowest are enlarging their business and widening their circle of customers. And although the increased traffic probably does not yield a profit at present rates, it creates a basis for improved prospects whenever a rational tariff may be again restored. In the true interests of the public we hope that this consummation may not be long delayed.

CORRESPONDENCE.

CURRENT INDUCTION AND LENZ'S LAW.

TO THE EDITOR OF THE ELECTRICIAN.

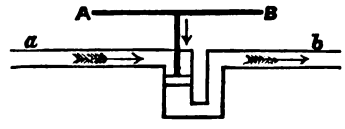
SIR: At an early stage of my heretical views about the process of induction, it was pointed out to me by a friend that my tenets were in direct opposition to Lenz's law. The antagonism which here exists will be made more clear if I deal with one particular case. When A B, part of a current-bearing circuit, is moved down upon *a b*, part of a passive circuit *a b s*, a current is found to flow through *s* during the operation, in the direction shown, and at the same time we experience a resistance to the movement of approach. These are the facts with which Lenz's law deals. With facts, however, I am not at variance; my quarrel is with the *rationale* of Lenz's law, which traces a certain connection between the resistance to the movement and the direction of the current induced in *a b*. According to the usual view of induction, it is *inferred* that the current through *s* passes all round the circuit, and therefore from *b* to *a*—viz., inversely to the direction of the current in A B. And thus the opposition to the movement of approach is attributed to a repulsion between the two wires, it being known that "inverse currents repel each other." Meanwhile, from my own point of view the current between *b* and *a* goes the other way, and is not inverse but direct in respect of



the primary current A B; so that Lenz's reason no longer applies. I thus impose on myself a twofold task. First, I must account for the mechanical resistance experienced without reference to any inverse, repellant currents, whose existence I disbelieve in; and, secondly, I must explain why the currents, if flowing, as I represent, both in the same direction, do not positively *aid* the movement of approach by their mutual attraction.

I. As regards the resistance experienced, there is no need to go in search of repellant currents to explain its existence; it is an *a priori* necessity, depending upon fundamental principles about action, work, &c. If the work of driving the induced current is done *ipso facto* by moving A B closer to *a b*, we are sure to experience an equal and contrary reaction according to the resistance overcome in executing this action. Briefly, if moving A B drives the induced current, the movement is sure to engender resistance to itself. I might make a similar remark about the reaction upon the primary current, known as the counter E.M.F.; for the primary current with its magnetic faculties is a co-factor in driving the induced current.

II. Next I have to answer the objection—Since parallel currents in the same direction attract one another, does not the heterodox theory require that the induced current should *attract* A B and encourage its approach? I reply that it makes all the difference whether the current in *a b* is due to some independent cause, or is produced by the approach of A B. In the latter case there is no reason why attraction should occur. A hydraulic illustration will best explain the matter. A current of water in the direction of the arrows, proceeding from



some independent cause, would doubtless draw down the piston and its cross-bar A B (which represents the attraction of parallel currents of similar direction); but if the current in the pipe is simply the result of pushing down A B (which represents inducing an electric current by the approach of the primary wire), no man in his senses will imagine that such a current will lend any active assistance in the pumping. In the same way the induced current caused by the approach of the primary wire is merely the process of yielding by which the movement is permitted. Undoubtedly this induced current does, in a *permissive* sense, favour the movement of approach; but it does not actively *assist* that movement. Otherwise we should have to throw away that good old maxim, *ex nihilo nihil fit*.

I cannot conclude without making one reflection upon the above hydraulic illustration. It seems to me to point out, in virtue of a general principle, that whatever may be the nature of that invisible molecular mechanism which connects the primary and secondary circuits, the current induced by a movement of approach can only be of such a kind as would cause attraction if independently produced, and that consequently the commonly accepted idea of a repellent current induced by approach is a physical impossibility.—Yours, &c.,

37, Burlington-road, W. E. ALDRED WILLIAMS.

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MILITARY TELEGRAPHY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Your interesting leader in last week's issue was particularly welcome to me, as it contained an expression of opinion on a subject which I was anxious to see brought forward at the discussion on Capt. Cardew's important paper. I was pleased to see that your article shows a decided preference for the Sounder as a military telegraph instrument. I expressed this opinion myself at the discussion on Capt. Cardew's paper, but should have naturally preferred for that opinion to have emanated from any of the officers experienced in military telegraphy.

The expression of one or a dozen opinions in favour of the efficient working of non-recording military telegraph instruments does not settle the question of their admissibility in a well organised army; nor does Mr. Donovan's reply to my question, as given at the discussion, in which he mentioned the well-known fact, so minutely described in Mr. Plum's lengthy work*, that "throughout the American Civil War non-recording sounder instruments were employed," as it is not proved in any way that American army organisations would be the proper organisation for European warfare.

I should like to say a few words on this subject; but before doing so wish to remove a slight error made by Captain Cardew, and by which the writer of your leader seems to have been influenced, which error is shown in the following words of the lecturer, viz.:—"The system, which was invented by me five years ago, has been kept secret by us hitherto." This is not quite correct, as Captain Cardew's apparatus was brought forward and explained to the public over two years ago.

Not going into the question of the supposed liberality with which you credit the War Department in letting everybody into its secrets, I may state that Captain Cardew's Vibrating Sounder has been mentioned, described, exhibited, or publicly explained on the following occasions:—"Telegraphing across the Solent without a Cable," published in the *Military Telegraph Bulletin*, March 15th, 1884, London, edited by Major C. Beresford, R.E. (Trübner and Co.). "Notes on Military Telegraph Instruments," by Major N. F. Turner, R.E., revised edition, London 1884. A copy of this very perfect book of information was presented by its author to the library of the Society of Telegraph-Engineers, and has been at the disposal of anyone interested.—"Review of Major Turner's above-mentioned Book," published in the *Military Telegraph Bulletin*, 15th September, 1884.—"Our Field-Telegraphs: its Work in Recent Campaigns, and its Present Organisations." Paper read by Lieut.-Colonel A. C. Hamilton, R.E., before the Royal United Service Institution, on February 15th, 1884, Major-General Sir Andrew Clarke, K.C.M.G, C.B, C.T.E., R.E, in the chair. On this occasion the vibrating-sounder was not only spoken of by the lecturer, by Lieut.-Colonel R. N. Jelf, R.E., and by Major Armstrong, R.E., but it was also exhibited and worked by non-commissioned officers of the Telegraph Battalion, and after the lecture it was minutely explained to everybody interested.—"The Inventions Exhibition at South Kensington," during the summer, 1885. A Cardew vibrating sounder was exhibited during six months, and inspected by thousands of people.—"The Field Telegraph: its Use in War, and its Employment in the late Expeditions in the Soudan and South Africa." Paper read in April, 1886, by Major C. Beresford, R.E., before the Royal United Service Institution. On this occasion Captain Cardew exhibited and fully explained his own apparatus.

Even a telegraph clerk of the Royal Engineers possessing a poetic nature, dismounting from the telegraph station waggon and rising upon his own Pegasus, dedicated an elegy to the musical "buzzer," animadverting, long before Major Beresford, on the buzzing sounds so trying to the ear. This piece of poetry appeared in the *Military Telegraph Bulletin* of April 15th, 1885.

With these remarks, which could be easily increased *ad infinitum*, there is not a shadow of doubt left that the paper read at the last meeting of the Society of Telegraph-Engineers revealed nothing particularly new, nor gave publicity to anything hitherto kept secret. Fortunately there is no secrecy in the organisation, formation, and material of any military telegraph, and as regards the "material" there could hardly be any. The very nature of the telegraph lines, stretched over immense distances, distributed over numerous stations, exposed to the eyes of thousands of people, often left behind in warfare, &c., all forbid secrecy. Thus, Major Beresford's pithy remark, that "the army which has the most efficient system of electric signalling will hold a trump card which may exert a decisive influence on the game in any future European war" is perfectly correct, but does not refer so much to the "material" as to the "*personnel*." In this latter centres the efficacy of a field telegraph service.

With your kind permission, Sir, I will now make a few remarks with regard to two points—viz, the efficiency of Captain Cardew's "Vibrating Sounder," and the question of admissibility of non-recording instruments in active service.

With regard to the efficiency of the apparatus, I believe that Captain Cardew did not bring forward at the Society's meeting all the arguments that might be used in favour of his own apparatus. Thus, for instance, Colonel (then Major) Turner, R.E., reported in his "Notes on Military Telegraph Instruments, with Diagrams of Connections," a book made public in 1884, as already mentioned, that "this system has been successfully worked through 15 miles of bare wire lying on the ground, and even when a part of the line was thrown into a canal the signals were perfectly readable."

Then Colonel Hamilton, R E, on the 15th February, 1884, lectured at the United Service Institution and said: The "vibrating transmitter has been introduced into our field telegraphs on account of the marvellous power which this arrangement has for being used on a defective line, so that in such a case as a bare wire lying on the ground from the poles being knocked down, or (as was sometimes the case in South Africa) the insulation being burnt off the cable by grass-fires, the transmitter would convey messages with great distinctness, whereas there would be an insufficient current received to work a recorder or a sounder. But the instrument has some defects, owing to its great sensitiveness, which rendered it, however useful on special occasions, unsuitable to the ordinary traffic of the service."

This was corroborated by No. 7, of the *Military Telegraph Bulletin* of the 15th of September, 1884, in the following words:—"Means have also been provided by Capt. Cardew's vibrating sounder, in combination with telephone receivers, to transmit messages for many miles through a wire lying uninsulated along the bare ground, and thus communication can now be effectively maintained under conditions which, a few years ago, would have rendered it impossible."

This information induced me more than a year ago to experiment with a vibrating sounder, and the following results of three experiments will give further evidence of the high efficiency and valuable qualities of the apparatus, especially when it becomes a question of working a badly insulated line.

1st Experiment.—A double wire circuit, having an artificial resistance of 100,000 ohms, with a vibrating sounder at one end and a telephone at the other; the line circuit being short-circuited half way by only 2 ohms resistance. With this arrangement the telephone received the vibrating Morse signals perfectly, with a battery power of only two Leclanché cells.

2nd Experiment.—Same arrangement as above; but instead of short-circuiting the line wire, the poles of the battery were short-circuited with a resistance of 2 ohms; the result obtained being as favourable as before.

3rd Experiment.—Line consisting of a single naked copper wire of 2 mm. diameter, 130 yards long, having an earthplate at each end. Ninety yards of this wire were thrown into the River Thames, and to the remaining 40 yards on shore, which were suspended on poles, an artificial resistance of 40 ohms was added. With this arrangement the distant telephone received the vibrating Morse signals with a battery power of six Leclanché elements; resistance of vibrating sounder eight ohms, and of telephone four ohms.

* "The Military Telegraph during the Civil War in the United States," by William R. Plum, LL.B. Two Volumes. Chicago: Janson, M'Clurg, and Co., 1882.

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Capt. Cardew's experiments, as well as those just mentioned, demonstrate the valuable qualities which this apparatus possesses, the chief of which may be summed up as follows :—

1. Possibility of telegraphing on badly insulated lines.

2. Employment of fewer cells, thus reducing weight for transport.

3. Light weight of apparatus, also facilitating transport; simplicity of construction, requiring little adjustment for altered condition of currents.

4. Note signals are more easily read than interval signals.

The utility of the Cardew vibrating sounder is thus established beyond doubt, and as its good qualities are exactly those required in field telegraphy, it is but natural that this apparatus should be hailed with satisfaction by everyone interested in this branch of the telegraphic profession. The possibility of working with very light wires of considerable strength, but badly insulated, is identical with the possibility of advancing telegraphic communication more towards the front, and thus increasing the hitherto limited sphere of field telegraphy. In this consists the prime value of the vibrating sounder.

But, alas! there is no rose without thorns. The vibrating sounder is a non-registering instrument, and can such be safely adopted by a well-organised service for military reports? This leads me to my second point.

I fully agree with your leading article that before we venture to discuss such a question it is necessary to define what we mean by military telegraphy. The object of such a service is to facilitate and hasten communication between more or less detached bodies of troops during military operations. Such operations, however, being of very distinct nature and variety, it follows that the telegraph service in the field must before all be adapted to the nature of the warfare on the spot. In this respect there are two main distinctions, viz., "advancing warfare" and "warfare in position." The two things are not identical, and the conditions to which the military telegraph service are subjected in the one case may be totally different in the other.

You mention in your article a "military telegraph which is always in front of the army." Is this not a theoretical aim only, and not a practical reality based on the history of the service? I accept the description with regard to warfare of position; but since electricity has been discovered the cases of a telegraph being in front of an army on a European theatre of war and in combination with the more important part of modern warfare—that of rapid advances—could certainly be counted on the fingers of one hand, and I even doubt if so many cases as that could be found. With the exception of the brilliant and unique telegraphic action of Colonel Sir Arthur Mackworth, C.B., R.E., during the short but glorious 1882 Egyptian campaign,* where the field telegraph acted on the battlefield at Tel-el-Kebir and also at reconnoitering expeditions, there is no case on record of an English field telegraph section having been at the front of the army during times of advancing warfare, and Sir Arthur's action took place during a campaign out of Europe, one of short duration and of limited extension. The telegraph operations during the Abyssinian, Ashantee, Zulu, Bechuana, Transvaal, Afghanistan, and Soudan campaigns had all the character of Etappe lines. The likewise brilliant telegraphic operations of Colonel Turner and Major Beresford at the front during the Eastern Soudan campaign could hardly be classed with "advancing warfare," as Major Beresford himself stated† that "the expedition which started from Souakim with Berber as its object did, in fact, not go more than twenty miles up country."

With regard to warfare in position every military authority agrees that troops operating under such conditions ought to be provided with every possible means of telegraphic communication, electrical as well as optical, and that these communications ought to extend over the entire field of operations, with ramifications beyond the head-quarters of army corps to the very outposts of the lines.

So far we meet with no difference of opinion; but when approaching the subject of telegraphic operations during "advancing warfare" we suddenly find ourselves upon a field of most diverging opinions. Major Beresford said, and many officers of various armies have long ago made similar remarks, "that in any future European war the army whose vedette and outpost service was equipped with efficient telegraphic appliances would possess a trump card of enormous value;" whilst other officers, also experienced and seasoned in telegraphic warfare, say just the reverse. Thus, for instance, Captain Baron von Massenbach in his article,* speaking of the German military telegraph organisation, says (pp. 138 and 140):—"Before all, we must point out that, as far as we know, an acknowledged necessity for an outpost telegraph service—that is to say, any mechanical means of communication forming an integral part of an army, does not even exist. Although we do not doubt that such a communication might occasionally be of convenience—in some situations even of advantage—to the strength of the army, we doubt very much whether the advantage gained in this respect is not lost many times over in other ways by adopting such a system. We flatly deny that, with the exception of a siege, an outpost telegraph could contribute a perceptible increase to the fighting capacity of the troops." Further on Captain von Massenbach says: "Let such outpost performances be transferred to our battlefields, and we will see where the telegraphists remain, where a judicious application of electricity ceases, and where child's-play begins," &c.

That these principles are followed in the German army is shown by the fact that the Field Telegraph Reglement only prescribes the daily connection between the base of operations with the great head-quarters and with the head-quarters of the armies. Telegraphic connection between these latter and the head-quarters of their army corps does not belong to the regular programme of German field telegraphy, and is only aimed at on special and favourable occasions, whilst still further advanced telegraph lines, for the purpose of connecting divisions or outposts, are not only excluded but are considered inadmissible during "advancing warfare."

I cannot help regretting that your leading article of the 4th inst. bases its criticism of German army telegraphs on pictures of illustrated periodicals. This detracts from the value of arguments, and leads to misapprehension. Besides, it remains an open question whether "pedantism" in military matters is a virtue or a vice. Anyhow, German telegraphists have not been so "comfortably seated at fitted tables" during the Franco-German war as those illustrated periodicals would make people believe. Evidence of this is given in the following figures:—During the time from the 16th of July, 1870, till May, 1871, the German Military Telegraph Department erected 27,841½ kilometres (17,293 English miles) of telegraph lines and 569 telegraph stations† for purely military purposes. If we compare this working efficiency with that of the military telegraphs during the civil war in North America, and with that during the last Soudan campaign, we have the following official figures :—

The total number of miles of U. S. military telegraph lines constructed,‡ including field, land, and submarines lines, amounted to 15,389 miles, occupying in time from the 12th of April, 1861, till the 1st December, 1865.

According to Major-General Webber, C.B., R.E., there was erected during the late Soudan campaign a grand total of 1,536 miles of line,§ ending at Hamdab, a couple of hundred

* "The Field Telegraph Operation in Egypt," by Major Sir Arthur Mackworth, R.E. Published in the *Royal Engineers' Journal*, 1st December, 1882, London.

† *Proceedings* of Society of Telegraph-Engineers and Electricians. Vol. XIV., No. 59, 1885, page 475.

* "Was wir von der Feldtelegraphie hoffen," by Baron von Massenbach, Captain à la Suite of R B. Engineers, published in the *Jahrbücher für die Deutsche Armee and Marine*, Vol. LIV., No. 12, and Vol. LV., Nos. 1, 2, and 3. [Berlin, 1885.]

† "Organisation der Elektrischen Telegraphie in Deutschland für Zwecke des Krieges." By Major-General von Chauvin. Berlin, 1884, Page 109. Also, "Der Deutsch Französische Krieg," published by the "Grosse Generalstab." II. Part Feldtelegraphie, page 1,437. Berlin.

‡ "The Military Telegraph during the Civil War in the United States," by W. R. Plum, 1882, page 349.

§ *Journal* of the Society of Telegraph-Engineers and Electricians, Vol. XIV. No. 59. 1885. (See map).

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miles at the rear of the operating front of the English expedition, and occupying in time for its establishment from the 18th of September, 1884, till the 1st of May, 1885.

If we bring these figures to an equal standard of time, we find that the actual working capacities of military telegraphs during the Soudan, the United States, and the Franco-German campaigns, stand in approximate proportion as 1 : 1¼ : 8½ respectively.

The conception of the "comfortably-seated German field telegraphist" most likely arose from the fact that the German Etappe lines even employed the Hughes printing apparatus, and this with very great success. Within a few months more than one million telegrams were handed over to the Versailles military telegraph station and promptly forwarded to Berlin, principally by the Hughes printer, hence "printed tape was sometimes delivered to commanding officers." The Hughes, as a military apparatus for Etappe trunk lines, possesses many advantages, amongst others that kidnapping of messages along the line is impossible. Such performances during the American war frequently happened at the front, but in a European theatre of war this could only happen at the rear. Therefore, under stable circumstances, during warfare of position, on main Etappe lines, the Hughes printer is an efficient military telegraph apparatus.

Now, whatever the drawbacks of the German military telegraph organisation may be—and there are some very serious ones—her so-called "pedantic" proclivities have, as proved by above figures, not interfered with her working capacity, which reduces that of the United States telegraphs to quite a secondary achievement, and meets no competition in the annals of the use of telegraphy in war.

After these facts I can now easily bring forward my last point. As already stated, the German army does not recognise the necessity and admissibility of an outpost telegraph service in "advancing warfare," hence she objects to any apparatus for such purpose, be it a vibrating-sounder or a telephone. The apparatus for outpost service during "warfare in position" are always recording instruments, and this kind of station apparatus is under all circumstances preferred to any audible apparatus. I mentioned this at the discussion on Captain Cardew's paper, and I now give as follows a few remarks of modern writers confirming this proposition, based upon German war telegraph experience:—

Major-General von Chauvin, whose distinguished fortune it was to command the military telegraph during the Danish, Austrian, and French campaigns, says on page 17 of his book: "Field telegraph apparatus must be simple and strong, easily manipulated and transported, and as little as possible influenced by changes of temperature, climate, or electrical changes of currents; and, above all, they must produce a record of the telegrams." And on page 87: "The use of the telephone, although a non-registering apparatus, could be exceptionally admitted on telegraph lines in fortified places, in order to connect detached forts with the commandant's headquarters."

Then again, Captain von Massenbach writes in 1885 (page 147) as follows:—"We consider both apparatus, the sounder and the telephone, as inadmissible on principle. We consider the loss of every control of the telegraph service, the abandonment of documentary confirmation of correspondence, and the want of responsibility of the corresponding parties, as entirely incompatible with the principles governing our army service and that of military reports and orders in the field. To introduce into our highly disciplined army, where the sense of duty and responsibility is diffused into the lowest branches of the service, an element so unsolid and uncontrollable would, indeed, not be a luxury, but an evil." "Who would in warfare sanction the possibility, nay, the likelihood, of numerous uncontrollable errors and mistakes caused by such an outpost telegraph—all such errors beyond control, and chiefly committed by subordinates, but sometimes incalculable in their consequences? Then, besides, in a foreign country, with foreign names to telegraph! Our conclusion is simple. Should an outpost telegraph be insisted upon, then let it have recording apparatus; but even this would be difficult to combine with our army organisation. Its technical prospects would be doubtful, its tactical prospects insignificant, the army does not ask for it and will never require it, hence—away with it!"

At page 262 the same writer says:—"The severe and scanty form of military intercourse, the never-ceasing and strict control of the service, are points which give the recorder a decided advantage over any non-recording instrument."

Then again: "The best constructed apparatus, the clearest and most correct notions of its application for war purposes have not yet produced successful results, and will not as long as the motive force bears the character of unreliability. If telegraphy is to become a factor of strategical calculation, then its failure must be quite an exception and not a probability."

Much more evidence against the use of outpost telegraphy in advancing warfare, and against non-recording military apparatus in general could easily be produced, but I must apologise for having already so far trespassed on your space. I have not expressed here my own opinion on the question, but this I have published repeatedly in several treatises on military telegraphy.* I, however, repeat here what I said at the discussion on Captain Cardew's paper, that under certain circumstances I am in favour of outpost telegraphy and of non-recording instruments, and there is no doubt that the vibrating sounder is the most suitable of all. In raising the question of admissibility of non-recording instruments for military telegraphs, my sole object was and is to invite officers of experience to exchange their opinions, and thus to contribute to the settlement of differences of opinion which certainly exist, and which so vitally influence the adoption of non-recording instruments in general. I am thankful to Major Beresford, Mr. Donovan, Captain Cardew, and, above all, to *The Electrician's* leading article, for having already expressed their opinion; but as none of these are given with the completeness which the importance of the subject merits, I hope that fuller accounts, expressed in a "service-like" manner, will come forward.—Yours, &c.,

R. VON FISCHER-TREUENFELD,
late Commanding Officer of Army Telegraphs.

The Glen, Balham, London, S.W., June 8, 1886.

ELECTROLYTIC TREATMENT OF ARGENTIFEROUS ZINC.

At Friedrichshütte, in Silesia, the following modification of the treatment of the zinc, lead, and silver alloy obtained in desilverising lead by Parkes's process has been introduced. The zinc-skimmings, averaging lead 90, zinc 8-10, and silver 0·5-2·0 per cent., are granulated and placed in a layer at the bottom of a lead-lined tub filled with a solution of sulphate of zinc, forming the electrolyte. The positive electrode is formed by the lead plate at the bottom, while the cathode is a zinc plate suspended vertically in the liquid. When a current of sufficient strength is passed through the apparatus zinc is deposited on the cathode, a corresponding quantity of the metal being dissolved from the granulated alloy, so that the strength of the solution is kept approximately constant. The decomposition goes on until the residual alloy, which may be about one-half of the regular quantity, is protected by the excess of lead from further action, when it is washed, dried, and subjected to liquation. By the latter operation lead is separated of sufficient purity to be passed at once to the refinery, while the residue contains zinc and lead in about the same proportion as the original zinc-skimmings, and is of the same fine-grained character. This is subjected to the electrolytic process a second time, followed by subsequent liquation. By these alternate operations, zinc, lead, and silver are obtained

* "Kriegstelegraphie, Geschichtliche Entwicklung, Wirkungskreis und Organisation derselben." Berlin und Stuttgart. 1879. F. Springer.
"Die Kriegstelegraphie in den neueren Feldzügen Englands, Afghanistan, Zululand, Aegypten." Berlin. 1884. Mittler and Sohn.
"Die neueren Militärtelegraphen-Organisationen." Published in Tahrbücher für die Deutshe Armee und Marine. Vol. L. Berlin, 1884.
"Was von der deutschen Feldtelegraphie zu hoffen ist." Published in Tahrbücher für die Deutsche Armee and Marine. Vol. LVII. Berlin, 1885.

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in the metallic state, instead of the mixed oxides of lead and zinc formerly produced in considerable quantity, which could only be made marketable with difficulty.—*Proc.* Inst. Civil Engineers.

EXPERIMENTS ON INDUCTION CAUSED BY MOTION.*

When a conductor is moved in a magnetic field currents are generated in it. Again, when a conductor traversed by a current is placed in a magnetic field it tends to be displaced in accordance with the rule of Ampère. These two phenomena are generally verified by employing solid conductors to place in the magnetic field; but there is evidently no reason why we should not employ liquid ones.

It is exactly on this employment that the mercury galvanometer of M. Lippmann is based, which gives a displacement of the mercury in the magnetic field when this liquid is traversed by a current. But it is known that M. Lippmann has also shown that this instrument is reversible, and that if we put the mercury in motion mechanically there is a development of electricity.

The currents which result from this induction in the mercury ought to be regulated by the law of Lenz—that is to say, they ought to be so distributed that by their electro-magnetic action they oppose the motion which gives them birth, producing the same resultant effect as a sort of friction in the magnetic field.

It may be proposed to arrange the experiment specially with the aim of showing this particular effect. For this purpose the iron core of a horse-shoe electro-magnet is terminated in two rectangular pieces of iron, which almost meet, but are just separated by a thin piece of cardboard, which is pressed tight between them. This cardboard is cut away in the centre, so as to make a channel between the rectangular pieces of iron which form the poles. This channel is very narrow in the direction parallel to the lines of force (the width being only the thickness of the cardboard). Perpendicular to the lines of force, however, it is much wider, and it widens out particularly at the centre, where the cardboard is most cut away. The two rectangular pieces of iron are encased in two sheets of wood or ebonite, and in these two glass tubes are fastened which meet the channel between the poles (formed by removing part of the cardboard). One of these glass tubes is connected with a reservoir of mercury by a caoutchouc tube, and the other ends externally in a fine point. The mercury can thus be made to flow between the poles of the electro-magnet, and, on emerging from the fine point of the glass tube, it forms a parabola as it falls. According to the direction of this pointed glass tube the mercury may have either a horizontal or nearly vertical velocity on emergence, and the form and range of the parabola will depend on the rate and direction of this velocity.

When the jet is well established, if a current is sent into the electro-magnet, the range of the jet immediately diminishes. and this diminution lasts as long as the current. This proves that the creation of the magnetic field in the channel opposes an obstacle to the free flow of the mercury.

This experimental arrangement has the advantage of enabling you to show clearly the strengthening produced in a current traversing a circuit by the extra-current of induction which arises on breaking the circuit. In fact, when the circuit of the electro magnet is opened, the summit of the new parabola, formed when the circuit was made, instead of returning immediately towards its primary position, undergoes first suddenly a slight further lowering, to rise again to its first level immediately afterwards.

It is easy to show the presence of the developed induction currents by introducing into the moving mass of mercury the extremities of two platinum wires. These currents are perpendicular, both to the direction of motion and to the lines of force of the magnetic field where they are developed. Hence these platinum wires should be introduced into the edges of the thin sheet of mercury which flows between the poles where the cardboard was removed. For the strongest effect the lines joining the extremities of the platinum wires should be perpendicular to the line of flow. A galvanometer, which is inserted between these wires, will show a deflection during the flow of the mercury, and this deflection will be reversed, either by reversing the magnetisation, or the direction of flow.

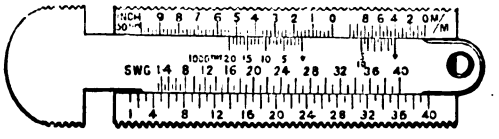
The E.M.F. thus generated will be constant as long as the flow of the mercury is constant, and it will vary with the velocity of the mercury.

The internal resistance and the E.M.F. are here both weak; hence, to show the production of the current readily, a galvanometer of small resistance should be used.

* Abstract of a paper by M. E. Colardeau in the *Journal de Physique.*

AN IMPROVED STANDARD WIRE GAUGE.

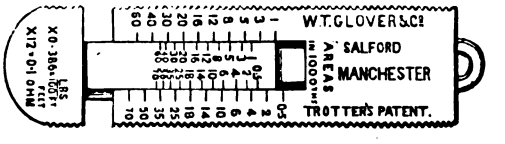
In our issue of 7th February, 1885, we noticed Mr. Trotter's then new wire gauge, and we have pleasure in again referring to it, in order to indicate the latest improvements. In its present form the gauge will register the legal number of any wire between No. 1 (·3in. diameter) or No. 40 (·0048in. diameter). Those who refer to our previous notice will see that it formerly only registered up to No. 6 (·192in. diameter) of the scale styled the S.W.G. (standard wire gauge). To those who are not familiar with the working of this particular scale, we may mention that the readings are obtained by the coincidence of the respective numbers.



Our illustration shows the gauge open, and is assumed to have just measured a wire which should have been No. 8, but which was rather under the size; hence the top figure has not quite reached its fellow on the lower part of the gauge. Had the wire been its proper diameter, it would have pulled the two figures No. 8 directly over each other, and the top and bottom marks would have appeared as one line.

It will also be observed that the inch scale gives the diameter in millimetres and the m/m scale the diameter in millimetres. It is worthy of mention that the inch scale gives a direct reading to a thousandth of an inch, and the m/m scale to a twentieth of a millimetre.

A further improvement, and perhaps the most important, is the extension of the area scale. This scale indicates the area in square inches of the wire that is measured, and works simultaneously with all the others; and therefore when a wire has been measured, its number and diameter ascertained, we need only turn the gauge over and there we shall find the area in *thousands of a square inch.* A reference to our engraving



will show what we mean, as the figures which *coincide* give the reading (like those of the S.W.G.). We should observe that the 20 marks are all but in accord with each other. Had our wire been a No. 8, as it should have been, then the area figures No. 20 would have paired each other correctly. By bearing in mind that only those figures are read which coincide no difficulty will be experienced in using this novel little instrument.

This area scale has other advantages, *e.g.*, if it is decided to run a current on the basis of 1,000 amperes to the square inch, then the readings may be taken as amperes direct, or if 2,000

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to the square inch, then the area multiplied by 2 gives the current a wire will carry on this basis. If the figures of this scale be taken simply as thousands, and multiplied by 0·4 (more accurately 0·386), we obtain the weight in lbs. per 100ft. of the wire measured; or, if multiplied by 20·35, we get the weight in lbs. per mile; multiplying by 12, we get the length in feet of copper wire, having a resistance of one-tenth of an ohm. 42·8 divided by the area gives the resistance in ohms per mile. Many other uses will, doubtless, suggest themselves to those who may use the gauge; in any case it appears to possess advantages which will readily commend it to electricians, wire users, and wire measurers generally. Now that the American Convention has recommended the use and adoption of our imperial standard for wires, perhaps our American cousins may find in this clever invention a by no means unworthy assistant in the attainment of such a desirable object.

The gauge has been brought out by Messrs. Walter T. Glover and Co., Salford, Manchester.

RESEARCHES UPON THE SELF-INDUCTION OF AN ELECTRIC CURRENT.*

BY PROF. D. E. HUGHES, F.R.S.

(Concluded from page 96.)

Influence of a Magnetic Sheath.

The remarkable phenomenon wherein a non-magnetic metal such as copper shows a higher "variable" resistance when under the influence of an external coating of iron than a wire of solid iron (and this notwithstanding that the resistance of the side of the bridge is kept a constant or by balancing its resistance on the opposite side G D as mentioned) seemed worthy of experimental research.

Experiments were made in order to find what form of conductor would give the maximum increased resistance in the variable period, and I found that an external tube of iron insulated from its central core produced this effect, for if the tube was not insulated but joined in electrical contact the results were reduced, due, I believe, to a transversal neutralisation taking place in its own portion of the wire, as I have mentioned in my reply to the discussion on my first paper.

TABLE III.—Influence of an Iron Tube upon an Interior Insulated Wire.

Iron gas tube, 90 cm. in length, 10 cm. diameter, 2 mm. thick. Wires 1 metre in length, 3 mm. diameter.	Comparative force of the extra currents.	Resistance in ohms, stable period.	Resistance in ohms, variable period.	Percentage of increased resistance in variable period.	Absolute increase of resistance in ohms.
Copper wire alone.	82	0·00460	0·00482	7	0·00022
Copper wire insulated in the interior of the iron gas tube	410	0·00460	0·03220	600	0 02760
Brass wire, ditto..	410	0 01380	0·03974	188	0·02594
Iron wire, ditto...	615	0·02944	0·05888	100	0 02944
Lead wire, ditto..	410	0·05750	0·08682	51	0·02932
German silver wire, ditto	410	0·07636	0·10384	36	0·02748

Table III. shows the effect produced upon an electric conductor by surrounding it with an insulated sheath of iron. It will be seen that the magnetic reaction of the tube upon the primary current passing in the wire produces a marked effect upon the different metals; the force of the extra currents as measured by the induction balance rise in value from 82 to 410, this being a constant for all metals except iron, which alone shows the higher force of 615. The force of the extra currents, however, has no direct relation to the extra resistance shown in the variable period, but the latter must be in direct relation with the duration or length of time required to pass from an infinite to the stable resistance.

The table shows on comparing the resistance of a metal in its stable period with that found in the variable, that copper has the highest percentage of increased resistance, being 600 per cent. increase, or seven times that found for its stable resistance, each metal in the order of their specific resistance having a less percentage of increased resistance until we arrive at the German silver wire, which shows only 36 per cent. against the 600 per cent. of the copper; we have also here the remarkable fact that iron even with a circular section stands simply in its order of specific resistance, showing only one-sixth of the increased resistance experienced by copper; the percentage of increased resistance of a metal when under the influence of an insulated magnetic sheath is directly as its conductivity or inversely as its specific resistance.

If we regard the phenomenon from a different point of view, confining ourselves simply to the additional resistance above that of its specific stable resisiance, all metals whether magnetic or non-magnetic have an almost invariable quantity dependent entirely upon the coefficient of the electro-magnetic action of the iron tube, and independent of the resistance or nature of the wire.

The experiments with an insulated iron sheath may be considered as a forced condition which does not occur or need not be taken into account, but the reaction of the iron tube is evidently electro-magnetic, and as our atmosphere is also magnetic, we may assume that its reaction would be similar, though in a far less degree to that which I have shown.

Submarine Cables.

The influence of a magnetic sheath upon an external insulated wire is one of vast practical importance in relation to our electrical submarine cables, as they are all constructed with an insulated wire surrounded by a spiral sheath of exterior iron wires. In order to study this question I made several cables of short lengths (1 metre) and found (most fortunately for our practical applications) that when the exterior iron sheath is divided as in a cable, or when the sheath consists of several large wires in close contact, that its effects are reduced to a mere fraction of what it would be if the external sheath was a continuous tube; this is entirely due (as I have shown in the case of stranded wires as compared with solid) to the imperfect formation of circular magnetism. I will cite a few examples illustrating this.

A cable was formed of a similar copper wire and insulation to that shown in Table III., the iron tube being replaced by eight iron wires (of 2 mm. diameter each) wound with a slight spiral of five turns per metre, this showed but 100 per cent. increase in the force of the extra currents against 400 per cent. increase when the same wire was in the iron tube; the increased resistance in the variable period was but 50 per cent. against 600 per cent. for the iron tube, or only one-twelfth of the additional resistance caused by the tube. These wires were replaced by galvanised iron wire, which prevented magnetic contact, and the variable resistance became much less, and when these were replaced by numerous fine iron wires the effect was reduced to the minimum found, or only 20 per cent. increased resistance in the variable period, or 30 times less than that of a solid iron tube of much less iron.

It is therefore evident that the circular magnetism plays an important *rôle*, and that most fortunately our cable manufacturers (without knowing the immense reaction which would be produced by a continuous sheath of iron) have constructed our cables with a protection of iron divided into several iron wires instead of a continuous iron sheath; there are, however, many telegraph lines which in passing through tunnels use a continuous iron tube as the protection, and therefore such lines must feel all the deleterious effects that I have shown to be caused by the reaction of circular magnetism.

Influence of Copper and Iron Cores upon the Induction and Resistance of Coils.

It is well known that a coil of wire has a higher self-induction than the same wire in a single loop, and that the coil has a still higher induction when we introduce an iron core. I have made, however, a series of experiments in order to measure the influence of a core upon the resistance in the variable period, and also note the influence exerted by the induced or eddy currents circulating in the core.

Table IV. shows some comparative results.

A helix was formed of an insulated silk-covered copper wire of 24 single layers, having an interior diameter of 2 cm., the object being to form a coil having as little mutual induction as possible, but which would be readily acted upon by any core of metal introduced; and in order to measure the high forces obtained an induction balance of great power and range was used, the method, however, being the same as that already described.

The helix alone showed an induction value for its extra currents of 460, and a feeble increased resistance in the variable period of but 10 per cent.; if we now introduce a core of solid copper of 1·75 cm. diameter and 5 cm. long, a great change takes place both in the force of the extra currents and the resistance in the variable period; the extra currents fall in value from 460 to 352, whilst the

* Read at the Royal Society, May 27, 1886.

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extra resistance is increased to 52 per cent. above that of the stable period. We have here a double and contrary effect; the reduction of the force of the extra currents and the increase in the resistance cannot be due to the magnetic nature of copper, but must be due to the induced or so-called "Foucault currents" circulating in the core. To prove this the core was replaced by another similar in every respect, but cut longitudinally to its centre; the currents now ceased to circulate, and the copper core had not the slightest effect either on the extra currents or the variable resistance.

This is is shown in the table, where for greater precaution a core of insulated copper wires replaced the solid core. Evidently the induced current in the core was the cause of the extra resistance; work was done by the primary current, and a loss of energy at the expense of the electromotive force of the extra currents, but in doing this work a resistance was produced which was no doubt caused by the currents circulating in the core. These currents required time, passing through the variable stage and thus producing from their electro-magnetic inertia an equivalent reaction and electro-magnetic inertia in the primary coil itself. That this inertia is due to the electro-magnetic character of the current and not to an electric current considered apart, is proved by the fact (which I have verified) that when we coil a wire into a coil of several superposed layers, its electro-magnetic reactions introduce a measurable resistance in the variable period precisely similar, though feebler, than that which would be produced by the reaction on the conductor of a magnetic body such as iron.

TABLE IV.

Helix formed of insulated copper wire, 1·50 metre in length, 2 cm. diameter, and 24 turns.	Comparative force of the extra currents.	Resistance in ohms, stable period.	Resistance in ohms, variable period.	Percentage of increased resistance in variable period.	Absolute increase of resistance in ohms.
Helix alone.....	460	0·02632	0·02896	10	0 00264
Same with a core of solid copper..	352	0·02632	0·04013	52	0·01381
Same with a core of insulated copper wire	460	0·02632	0 02896	10	0·00264
Same with a core of solid soft iron	2338	0 02632	0·09870	275	0·07238
Same with a core of 445 separate fine iron wires, each 0·25 mm. diameter.....	5360	0·02632	0·04448	69	0·01816
Same with a core of silk-covered fine insulated iron wires	5820	0 02632	0·04075	55	0·01443

The effect of a solid iron core and a bundle of iron wires on the increase of the force of the extra currents is well known, but the table shows an interesting result as to their effects on the variable resistance; the solid iron core shows a very high force of extra currents produced by its magnetic reaction on the wires of the helix, the resistance in the variable period has increased 275 per cent., and its extra currents are extremely high, as we should expect. Now, if the extra resistance is due to magnetic reaction alone it should increase when we are enabled to increase this reaction, but if it is due in greater part to the electro-magnetic inertia of electric currents circulating in the bar, then by preventing these currents from being formed (as we did in the case of copper), we should greatly reduce the extra resistance. This proved to be the case, for on replacing the solid iron core by a bundle of fine iron wires the force of the extra currents rose from 2,338 to 5,360, or more than double the force of that produced by a solid bar, whilst the resistance in the variable period fell from 275 to but 69 per cent.

It is well known that a bundle of fine wires magnetises quicker than a solid bar, and this may have had its effect, although not more important than the suppression of the eddy currents, as the latter may be the cause of the former. The table shows that where we have suppressed these currents as far as possible by introducing a core of insulated wires containing less iron than in the previous experiment, but fully insured against eddy currents, the induction was the highest and the resistance the lowest yet found for a helix containing an iron core. The experiment proves to my mind that the extra resistance found in the three last experiments is due both to the electro-magnetic inertia of the eddy currents, and the inertia of the magnetic molecules of iron.

The experiments related in this paper have been most carefully made and verified, and from the ease and certain action as well as the invariable results obtained by the method which I have described, they should be easy to repeat by others.

If we regard the whole of these researches we cannot fail to notice certain important laws which act in the greater portion of them. I have shown:—1st. That the contiguous portions of the same current react upon each other in the interior of its own portion of the conductor similar to their known exterior reactions on separate portions of the same conductor. 2nd. That the coefficient of mutual induction is less in iron than copper wires, but that their coefficient is the same when the conductor is in the form of a ribbon. 3rd. That the inductive capacity of different metals depends on their specific resistance, on their electro-magnetic capacity for circular magnetism, and on the geometrical form of their conductors. 4th. That the inductive capacity of a conductor of magnetic metal is dependent upon the formation of circular magnetism and not upon its internal magnetic permeability. 5th. That a magnetic metal can be rendered equally free from circular magnetism as the non-magnetic metals. 6th. That we have experimental evidence of electro-magnetic inertia and the deleterious effects of eddy currents in the cores of electro-magnets.

In addition to the above effects, we have the discovery of a large increase in the ohmic resistance during the variable period, allowing us to demonstrate and measure the gradual rise of an electric current in its conductor.

In conclusion, I desire to express my warmest thanks to Lord Rayleigh, Mr. F. L. Pope, Prof. Forbes, Dr. Hopkinson, Mr. W. H. Preece, Dr. Fleming, Mr. FitzGerald, Prof. Silvanus Thompson, and Prof. Ayrton, for the important theoretical contributions they gave on the discussion of my first paper. Mr. W. H. Preece, electrician of the Post Office, not only gave information of great practical value, but has kindly supplied me with the wires used in these experiments. The discussion proved the necessity of the researches which I have undertaken, and the importance of an experimental determination of the self-induction of an electric current in relation to the nature and form of its conductor.

PHYSICAL SOCIETY.—June 10th.

ELECTRIC LIGHT FIRE DAMP INDICATOR.

At the last meeting of the above society the following paper on this subject was read by Messrs. Walter Emmott and William Ackroyd:—

The Royal Commission on Accidents in Mines point out in their recently issued report a serious objection to the use of the electric light in mines, notwithstanding its many other great advantages in that the light of an incandescent lamp being produced within a vacuum cannot admit of any device for the indication of fire damp, such as is employed in the Davy for example. This difficulty was experienced by one of us in the course of an installation of the electric light in the Lofthouse Pit, Wyke, Yorks., in the summer of 1885, and we have since made a series of experiments with the object of devising a method of making the electric light an indicator of fire damp. The apparatus placed before the Physical Society is the outcome of our work. It consists of two incandescent lamps, one with white glass and the other with red, and other necessary adjuncts, such that in an ordinary atmosphere the white incandescent lamp alone shines, but in fire damp the white lamp goes out and the red one begins to emit its light. This is effected as follows:

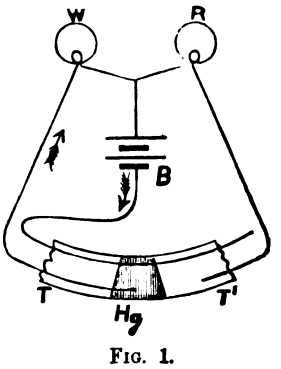

FIG. 1.

A porous pot of unglazed hard baked porcelain is joined by air tight connections to a tube, a portion of which is represented by T T¹ (Fig. 1). This tube is of such an internal diameter that it will readily admit of being sealed with a small quantity of mercury, H *g*. A platinum wire runs the whole length of the tube, and is connected with one of the poles of the battery B, or other source of electricity. Two other platinum wires in the tube run parallel with this for part of the way, as in Fig. 1, and

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each is connected with a lamp. The lamps W and R are joined, and a branch wire connects them to the other pole of the battery. In Fig. 1 the current is represented as flowing through W; when from diffusion in an atmosphere of fire damp the conducting plug H g is driven up to T^1 the current will flow through R, and the red light may then be taken to indicate the presence of fire damp.

The wires being within the tube, one or other of the lamps must always be shining so long as there is a current, whether the apparatus be in an atmosphere of fire damp choke damp, or air; and to prevent the mercury being driven out of the tube by too much pressure, bulbs are arranged on either side, as in Fig. 2, which presents a diagrammatic view of the apparatus. We have found an internal diameter of tubing of about 3mm. best adapted for ensuring easy mobility of the mercury. The presence of the wires within the tube has interfered with the perfection of the seal; this we have overcome by the introduction of a little concentrated sulphuric acid, which also serves the purpose of preventing sparking and of lubricating the interior. The use of sulphuric acid necessitates the addition of dessicators a and b (Fig. 2) to each end of the tube, but in cases where it

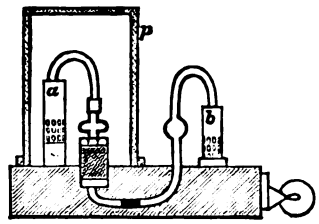

FIG. 2.

p Porous pot. a and b Dessicating tubes.

has been found advisable not to use sulphuric acid, both the acid and the dessicators have been dispensed with by slightly modifying the arrangement of the wires at the lower part of the tube. With this form of apparatus we are readily able to detect the presence of 5 per cent. of coal gas in a mixture of this gas with air, and with a mercury seal of less weight and closer proximity of the wires at T and T^1 (Fig. 1) it appears possible to get any required degree of sensitiveness. It is proposed to have the apparatus fixed in the main roads and hauling roads in pit installations.

COMPANIES' MEETINGS.

Australasian Electric Light, Power, and Storage Company (Limited).

The fourth ordinary general meeting of this Company was held at the offices, 41, Coleman-street, on the 11th inst., under the presidency of Mr. Philip Falk.

The SECRETARY (Mr. J. H. Duncan, F.C.A.), read the notice convening the meeting, and the report of the Directors was taken as read. The balance-sheet was submitted as at Dec. 31 last, and the profit and loss account for the 18 months from 1st July, 1884, to the same date. The profit and loss account, it was stated, "has been divided into two, with the view of clearing the trading account (proper) of sundry charges, such as the New Zealand loss, arising from the early history of the Company, and an analysis is likewise submitted, with the view of dividing up the account into the three successive half years embraced in the period since the former report." The result of this analysis was as follows:—Loss for the half year ended December, 1884, £2,474; for the half ended June, 1885, £1,685; and for the half year ended December, 1885, £111. The report also stated:—"Since last reporting to the shareholders the prospects of electric lighting in the colonies have become of a decidedly more settled character. What seemed at one time a likelihood of the Electric Lighting Act of the Home Parliament being adopted in Australia has passed away in consequence of that Act having admittedly proved in England a dead letter. Private enterprise in electric lighting, therefore, if not yet clothed with those privileges which will sooner or later become necessary, has not been hampered as it has been in this country. Mr. Want (till recently a Director of the Company) having occasion on other business to visit the colonies, courteously offered to confer with the General Manager in Australia, and to render any assistance in his power, and the Directors consider that thanks are due to Mr. Want in the matter. Since the date of the last report, two Directors, Mr. Randolph C. Want and General Meade Hamilton, have retired, and the Directors have elected Mr. B. H. Van Tromp and Mr. Aymor H. Sanderson, as members of the Board."

The CHAIRMAN, in moving the adoption of the report and balance-sheet, said that his remarks would necessarily be very short, for they had to get this meeting over rather early, for this reason: that the Edison Indian and Colonial Company were holding a meeting that day at four o'clock, and they would want to know whether the shareholders of the Australasian Company had ratified the agreement proposed between the two, and to which he would refer later on. His colleagues and himself confessed that they were disheartened, and at the same time dissatisfied, with the result of their working for the last eighteen months. They had tried as far as they could to reduce every expenditure on this side as well as in the colony, and, as the shareholders would see, the loss for the past six months was comparatively infinitesimal—only £111; but they had expected to do better than this. The Directors, however, believed that at the next meeting they would be able to show that, by cutting down the expenditure at both ends, and by carefully fostering all the work they could obtain on the other side they would be able to show a small profit. As far as he was able to see he thought they were just turning the corner. If the times in Australia had been better they would have had more public support. What they had been anxious about was that they should sublet, so to speak, to companies on the other side, their patents, &c., the value of which, he might observe, had of late been very materially improved. For one reason and another, things throughout the colonies had been in such a dreadful state in the last few years that they could not get people to entertain any proposal in that direction. If, however, they could only wait a little longer he felt satisfied that such a period would arrive, and they would take advantage of it. He did not know that it would serve any particular purpose to weary them with a recital of the non-success of the Company in the past, but it would be some satisfaction to him—and he was sure it would be to his colleagues, and it was only due to the shareholders—to state some of the causes why they had not been able to make greater progress. There were a good many reasons which he could assign for it, but among others he might mention that they began life, so to speak, with great expectations. They went to a new field, and they expected that they would be able to make a very handsome thing out of the enterprise; the expenses on both sides—more especially in the colonies—were very large; the work they had done was of a tentative nature; the opposition they had to meet with on all hands was very great, the various companies all striking out with the view of showing that their system was the best. That system, had, so to speak, crippled the Company. They could not get people in the colonies to take the matter up. By working against this unwholesome competition a very large amount of their legitimate capital had, up to a certain date, been constantly dropping off. The next thing was that the times had been against them, both here and in the colonies. As the shareholders knew, all the electric lighting companies in this country had suffered, and this state of things had naturally reacted on the colonies, for whatever occurred here was cabled out to the colonies, where people would have nothing to do with anything that was not thoroughly established. If they would consider all these difficulties he believed they would come to the conclusion that the Directors had—in the interests of the shareholders and of themselves—done the utmost they possibly could in the circumstances that had existed. If that were the view of the shareholders, the Directors would be encouraged to go on on with their efforts. If the shareholders should think differently it would kill whatever little ardour there was left in the Directors. A large expenditure was entered on in the past, because it was believed by the people who had the management on the other side that it was only by that means—by having a large quantity of plant, great premises, and a number of engineers running all over Australia, trying to outdo everyone else—that the Company could become successful; but all this meant a large expenditure of capital, and in the colonies everything happened to be twice as dear as in this country. Believing in their officers, in whom every trust was reposed, all this outlay was sanctioned. In domestic affairs, when prosperity prevailed, the expenditure was heavy in a variety of ways, but when bad times came they had to look around and see where retrenchment could be exercised. It was much the same with companies, and their Company had gone through such an experience, to their cost. It was, however, so far he could see, utterly impossible for them to have acted differently, unless they could have foreseen things miraculously. They had been disappointed, it was true, but that did not say that better times were not in store for them, more especially under existing circumstances. If figures showed anything, they demonstrated beyond a doubt that the Company were now, at all events, on the high road to see their way. [A Voice: "Bosh!"] That might be the opinion of one gentleman who had always favoured them with his presence at these meetings. He only hoped that they would see him among them from year to year, and that he would have occasion to reverse his opinions. He (the Chairman) could assure him that if he were placed, as they were at the Board, in a position to watch the business closely, he would come to a different conclusion. As the shareholders were aware, the Company were partners in the Australian Electric Company (Limited), of Melbourne, in which they were the largest shareholders. In fact, as would be seen from the balance-sheet, they held 18,000 shares in that company, which had already completed their lighting station, and they were now beginning to pay. They were also making strenuous efforts to extend that lighting station, and they themselves were hoping to reap some benefit at all events from the dividend which the other company might declare. In amalgamating with that company, or affiliating it with their own, they had got rid of a great opponent, and now that the thing had been worked round pretty well, they saw already that there was a dividend in the case of the other company, in which case their own Company would benefit to the extent of their holding. They were now proposing a very important arrangement with the Edison Company, as referred to in the report. With reference to the inquiry that took place last year into the affairs of the Company, when the committee finished their investigation they came to the conclusion—as already anticipated by the Board—that every effort should be made to place the Company, both here and in the colonies, on the basis of the smallest possible expense. That had been done. The hands of the Directors had been strengthened by the fact that one of the members of the committee had been appointed a Director, and had gone thoroughly into the position of the Company. That gentlemen had worked with the other members of the Board in harmony during the whole of the time since his appointment.

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They had given that gentleman every possible opportunity to try and find out if there was any hitch anywhere, so that he might indicate to the committee or the shareholders anything which he might feel required to be remedied. Mr. Van Tromp (the gentleman referred to) was now present, and might say a few words; and if he could mention anything which might bring about an improvement in the position of their affairs, such information would be gratefully received by the Directors generally. It was expected that if the arrangement with the Edison Company were ratified, Major Flood Page would probably join the Board of the Australasian Company. Major Page had visited Australia on behalf of the Edison Company, and had valuable information that would no doubt be to the advantage of the Company. He would not detain them any longer, though he had several notes before him, and he would conclude by moving the following resolution: "That the report of the Directors now submitted, with the accounts thereto annexed, be and it is hereby received and adopted."

Mr. B. H. VAN TROMP, in seconding the motion, said that when he first went on the Board, having regard to the inquiries that had been made by the committee, to the minute and close examination which the committee—including himself— had made into the previous operations of the Board, and their conduct in carrying on the affairs of the Company, he was under the impression that there had been grossly mistaken management in some respects, and expenditure which might have been avoided, but certainly he had not come on the Board with the impression that any gentleman had done anything that was dishonourable, and after working with them eighteen months that impression was confirmed. The Directors were men of honour and gentlemen, who, to the best of their belief, had conducted the Company for the benefit of the shareholders. It was not for men to command success, but he believed that the Directors had deserved it. During the last eighteen months he had attended, with one exception, every Board meeting of the Company, and also the committee meetings, and he ventured to say that if he had known the enormous labour and anxiety which a seat at the Board entailed on any man having to earn his living, as he had, as a professional man, he would have hesitated very much before accepting the position. Nothing relating to the Company had come from the colonies which he had not seen. The able Secretary had assisted the Directors to the very best of his great ability in carrying on the affairs of the Company, not only as regarded this country but on the other side. The Directors thought that in carrying out the proposed arrangement with the Edison Company they had, as it were, put on the crowning arch of the building, and it might possibly lead to a success in Australia which at that moment one could scarcely imagine as possible. If any shareholder were offered 20s. a share, with the liability of the call of £1 per share, he would not advise him to sell. That was his view of the position of the Company. The Directors were prepared to answer fairly, and without the slightest reservation, any question which might be put to them concerning the accounts or any of the affairs of the Company. He would not refer more to the Edison Company, as that matter would be dealt with afterwards; but he asked them to believe that the Board had done, and would do, if they were re-elected, the very best they could for the shareholders and themselves as shareholders; and they confidently believed that they would be able yet to make the Company a dividend paying company. They did take some credit to themselves for having carried on the Company for 18 months without asking the shareholders for one shilling. The Board had made themselves responsible for advances, but they were anxious to see whether, in alliance with the Edison Company, they might not be able to avoid calling up the whole of the uncalled sum. He asked the shareholders for their cordial assistance, without which no Board could make a company a success.

Mr. BENJAMIN KISCH said that having within the last 18 months had an opportunity of looking into the prospects of the Company, he would like—he admitted it was on imperfect knowledge—to confirm all that Mr. Van Tromp had said. Gentlemen present would probably remember that he (the speaker) was one of those who served on the committee who investigated the affairs of the Company. He and all the other members of the committee approached the subject with quite open minds, and when they last met there were a considerable number of persons who thought that the wiser course would be for them to save what they had and wind up the Company. That was an opinion very generally expressed. It was one on which at the time he could not express any view, as he had not sufficient knowledge of the affairs of the Company, but after the opportunities which he had had, in common with the other gentlemen who investigated the affairs of the Company, he had come very decidedly to the same conclusion as the Chairman and Mr. Van Tromp—that it would be an exceedingly unwise thing for them now to wind up. He did not consider that they were now walking on their last plank; on the contrary, if electric lighting was to revive and to become anything in the future, he should think the chances of Australia ought to be at least as good, and for many reasons better, than in many other parts of the world. No doubt, in consequence of past misfortunes, their capital account was overloaded, but whether they wrote it down or not, they knew that a large amount of it was practically written off. If in the future, as they had every reason to hope, some dividend might be able to be declared, he should think it would be a matter upon which they might congratulate themselves, even if the dividends were small. Certainly their prospects at the present moment would not warrant them in winding up, and he hoped they had now heard of that suggestion for the last time.

Mr. W. T. MORRISON said that they all knew that the adoption of the electric light had been of slow growth, but from evidence around them he thought that their Company, like some of the others, would do better in the future than in the past. He agreed with the last speaker that it would be most unwise to wind up; and if they were to take that step they would have to call up everything. He thought that the best plan was to leave matters in the hands of the Board, and leave them to do the best they could for the Company. They had heard from the Chairman and Mr. Van Tromp that their prospects were better than in the past, and judging from the prospects of electric lighting generally, he thought they might hope for something better than they had at present had from Australia.

A SHAREHOLDER asked what was the actual result of the last call.

The SECRETARY: £23,200 out of £24,000.

A SHAREHOLDER said that during a recent visit to the colonies he had had every opportunity of seeing in Australia what the Company were doing, and he had bought 100 shares. In his opinion a great deal depended on the amalgamation with the Edison Company, and in that case he believed that there was a possibility of the Company at some time or other paying a dividend.

After a few observations from Mr. PEARSON, who had served on the committee, and who said he thought that matters should be left in the hands of the Directors,

The CHAIRMAN put the motion and it was carried *nem. con.*

Mr. PEEK then proposed the re-election of all the Directors—Messrs. J. J. Cater, Latimer Clark, C.E., Philip Falk, Aymor H. Sanderson, and B. H. Van Tromp. He thought that, considering the undertaking had been such an unfortunate affair—in fact, like almost every electric company—the Directors had shown a vast amount of pluck, energy, and courage in trying to pull the shareholders through. When there was some discussion as to whether they should be replaced by others or whether the Company should be wound up, he strongly supported them because he saw that they were determined, if they could, to bring the Company round; and with the valuable assistance of Mr. Van Tromp he was sure that they had been redoubling their exertions. If there were a chance of pulling the Company round and making it a dividend paying concern they would do it, and, as far as he could see, there seemed to be hope that they would pull through. [Mr. Van Tromp: Hear, hear.] He knew that one or two gentlemen on the Board were quite convinced that the Company had turned the corner, and by the skill and energy of the Directors—who as men of honour were bound to do their utmost to make the concern a success—he was in hopes that they would become a dividend-paying company.

Mr. MORRISON seconded the motion, which was carried unanimously.

The CHAIRMAN, on behalf of his colleagues and himself, thanked the shareholders for their confidence, and assured them that the Board would endeavour in the future, as in the past, to bring the Company through its difficulties.

Mr. PEARSON next proposed the re-election of the auditors, Messrs. Deloitte, Dever, Griffiths, and Co., at a remuneration of thirty guineas.

The motion having been seconded, some discussion ensued as to the amount of the fee, it being contended that in the present position of the Company every penny that could be saved ought to be saved. Ultimately,

On the motion of Mr. MORRISON, seconded by Mr. STOBART, an amendment was passed, reducing the amount to twenty guineas.

An extraordinary general meeting was then held, to consider the approval and ratification of an indenture, dated the 20th ult., made between the Edison Indian and Colonial Electric Company (Limited) of the first part, Thomas Alva Edison, of Menlo Park, New Jersey, United States of America, electrical engineer, of the second part, and the Australasian Company of the third part; and of a series of resolutions for giving effect thereto.

The CHAIRMAN proposed the first resolution, approving and ratifying the indenture.

Mr. CATER seconded the motion.

A SHAREHOLDER asked what the advantages of the arrangement were.

The SECRETARY stated that by the arrangement proposed the Company would acquire the whole of the patents (with all improvements up to a certain date) of the other company, who had hitherto been their competitors. Those patents also covered India and the Cape, though for a time possibly they would only be able to do an indirect business in those places. In connection with that matter there was, perhaps, some importance to be attached to the success which the Edison Company had recently obtained in establishing their patents. Probably they would derive benefit from that in the shape of royalties in India and the Cape. They would also have from the other company their book debts, amounting nominally to £2,547, and their plant, which stood, at cost price, at £4,925. They themselves, however, did not put those values on those items. Against these advantages they would allot to the Edison Company 34,513 ordinary shares of £1 each, being one share for each share the Edison Company had in issue. These shares, in case of a distribution of assets, would only rank alongside the existing shares of the Company, which were called "original shares," for one-half their nominal value, or £17,256. 10s. Therefore, in the event of a distribution of assets that was the amount they would have paid for the patents, the book debts, and plant of the Edison Company. On the other hand, in order to facilitate the amalgamation they were to receive from the vendors of the company £18,145 in fully-paid ordinary shares; so, in point of fact, it was really the vendors who were purchasing the arrangement for the Company, and not the Company themselves. Moreover, the existing, or original, shares were to take 1 per cent. dividend out of the profits of the Company before the ordinary shares given to the Edison Company received anything; and, after that, the original and the ordinary shares would participate equally up to 10 per cent. for dividends. After that rate had been paid, the 34,513 deferred shares which they were also going to give to the Edison Company would begin to rank. In reply to a question, he stated that before they paid any dividend the Directors had the right to lay aside a reserve fund. Continuing, he said that the voting power had had to be changed, but it had been reserved

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very much in the hands of the original shareholders. They would have five votes for every £5 share, while the ordinary share and every ten deferred shares conferred one vote each. In addition to the £18,145 in shares which the vendors had relinquished for the purpose of the arrangement, there was a sum of £3,010 relinquished of the founders' shares, leaving only a nominal amount for founders' shares. There were two points stipulated for by the Edison Company. One was that Mr. Edison should reserve the right to an exclusive license for the application of his patents to locomotives on railways, tramways, or common roads. That was a stipulation made by Mr. Edison in selling the patents to the Indian and Colonial Company. The other stipulation was that in case anything should happen to make the Australasian Company wind up before March 1, 1889, such of the Edison patents as should not have been dealt with should revert to Mr. Edison. That, however, was quite a nominal condition. They would have to pay certain trade debts of the Edison Company on this side amounting to £163.

In reply to Mr. Kisch,

The SECRETARY stated that the founders' shares would take two-fifths of the surplus profits after a dividend of 10 per cent. had been paid and a reserve fund provided for. By the proposed arrangement the two-fifths surplus profits would be divided among the 2,000 shares which would remain in the hands of the founders, and the 3,000 which would be held by trustees for the Company.

The CHAIRMAN, in answer to a question, said that the Edison Company were the only competing company in Australia of which they were aware.

The SECRETARY, however, stated that the Gülcher Company had done a little in New Zealand.

The CHAIRMAN, in further reply, said that the committee that was appointed last year agreed with the Directors that it would be a step in the right direction if they were to take over the business of the Edison Company. The harm done to them by that company was in constantly competing against them. If the arrangement did no more than remove an obstacle of that description to their progress they would be in a better position by effecting it.

Mr. STEPHENS spoke in favour of the arrangement, and

Mr. MORRISON said he thought there could be no doubt as to the advantage of the proposal.

The motion was then carried, and the other resolutions were also severally agreed to.

The CHAIRMAN having intimated that a confirmatory meeting would have to be held in about a fortnight,

A resolution was passed thanking Mr. Want for the assistance he had rendered the Company during his late visit to Australia.

A vote of thanks to the Chairman and Directors was afterwards passed, and the meeting then separated.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. JUNE 16.		BUSINESS DONE WEEK ENDING JUNE 16. Highest.	Lowest.
Anglo-American	32,	33	32	—
Do. Preferred	53,	54	53½	53
Do. Deferred	10⅜,	11¼	10⅜	—
Brazilian Submarine	10½,	10⅝	10 11-16	10½
Cuba	10½,	10⅝	10⅝	10⅝
Do. Preference	18,	19	—	—
Direct Spanish	1½,	2	—	—
Do. Preference	9,	10	—	—
Direct United States Cable	9,	9½	9⅜	9
Eastern Telegraph	10⅜,	11	11	10⅜
Do. 6 per Cent. Preference	14½,	14½	14 5-16	—
Do. 5 per Cent. Debentures, 1899	105,	108	—	—
Eastern Extension	12⅛,	12⅜	12⅜	12⅛
German Union	9½,	9⅝	—	—
Globe Telegraph and Trust	6½,	6⅝	6 11-16	6½
Do. Preference	13⅛,	13⅜	13 5-16	13 1-16
Great Northern	12½,	12⅝	12 15-16	12⅜
Indo-European	33½,	34½	34½	34
Reuter's	6,	6½	--	—
Submarine	200,	210	—	—
West India and Panama	½,	⅝	⅝	—
Do. 1st Preference	8,	8½	8 3-16	—
Western Brazilian	7⅛,	7⅜	7 5-16	7⅛
Western Union 7 per Cent. 1st Mortgage	118,	122	—	—
Do. 6 per Cent. Sterling Bonds	103,	107	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	13-16	15-16	⅞	—
Oriental	3-16	5-16	—	—
United Telephone	13⅛,	13⅜	13 11-16	13⅛

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	2,	2¼	—	—
Do. (fully paid)	3⅞,	4¼	—	—
Swan	1⅝,	1⅞	1 9-16	—
Maxim-Weston	3-16	5-16	—	—

MISCELLANEOUS.

Telegraph Construction	37⅛	38½	38½	38⅛
India Rubber, Gutta Percha, and Telegraph Works	22⅛	23⅛	23⅛	23

TRAFFIC RECEIPTS FOR MAY, 1886.

COMPANIES.	May, 1886.	May, 1885.	Increase.	Decrease.
Cuba Submarine	3,050	3,736	—	686
Direct Spanish Telegraph	1,688	1,352	336	—
Eastern Extension	41,037	50,016	—	8,979
Eastern Telegraph	50,741	61,327	—	10,586
Great Northern	22,480	—	—	—
West Coast of America	3,450	—	—	—

THE BERNSTEIN ELECTRIC LAMP CO.,
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9a, COMMERCIAL ROAD, PIMLICO, S.W.
Manufacturers of the Bernstein Incandescent Lamp. Lamps from 5 to 100 candle-power. Lamps made to fit any kind of Holder already in use.
The Company have acquired the Patent Right of the Bernstein Lamp for England and Colonies, Belgium, Italy, Russia, Spain, and Portugal, Sweden and Denmark Particulars and Price Lists on Application

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Manufacturers of
Déry, Blathy, & Zipernowsky's Secondary Transformers.
Electric Light Installations carried out.

WILLIAM BANKS,
ELECTRICIAN,
CONTRACTOR for ELECTRIC LIGHTING and ALL KINDS of ELECTRICAL ENGINEERING,
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Telegrams, "BANKS, BOLTON." Works, BARK STREET.

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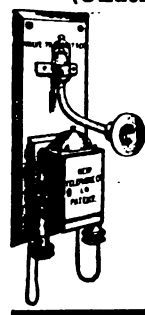

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NOTES.

TELEGRAPH CABLE REPAIRED.—The cable of the Paris and New York Telegraph Company is repaired.

ALGIERS.—Authority has been given for the construction of the first subterranean telegraphic line in this French colony.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 18th inst. amounted to £2,677.

REDUCING RATES.—Our advertising columns give particulars of the reduced rates over the lines of the Eastern and Eastern Extension Telegraph Companies to be applied from the 1st proximo.

CHELSEA.—On another page we discuss the provisional order, granted this year by the Board of Trade, authorising the Chelsea Electricity Supply Company to supply electricity within the parish of Chelsea.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended the 15th inst. are £2,460, as compared with £3,050 in the corresponding period of 1885.

VICTORIA.—Allowing for the difference of time, the telegraphic announcement of 69 words by which the Governor of Victoria announced the opening of the exhibition at Melbourne was transmitted to London in about 23 minutes.

THE FRENCH TELEGRAPHIC SERVICE.—Our contemporary *Electricité* is very hard upon the service, stating that the management is in a state of "inferiority" in comparison with that of any other country in Europe or America.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 18th inst. were £2,110, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

THE GRAPHOPHONE COMPANY.—This company, owning the patents of Mr. Bell's newest invention in telephones, has its legal *habitat* in Alexandria, Va., having been chartered in that city under the name of the Volta Graphophone Company.

THE FIRST ELECTRIC-LIGHTED CITY.—The first city in Europe where electricity has been entirely substituted for gas for street lighting is Hernosand, in Sweden. The motive power is water, which is very plentiful there, rendering the electric light cheaper than gas.

THE SOCIETY OF TELEGRAPH-ENGINEERS.—Prof. Hughes, F.R.S., president of this society, and Mrs. Hughes have invited the members to a *conversazione* at the Royal Institute of Painters in Water Colours, 191, Piccadilly, on the evening of Tuesday, 29th inst., from 9 to 12.

WEST AFRICA.—The West African Telegraph Company has opened a station at Bathurst, and on Sunday received a telegram thence stating that as Sir Samuel Rowe, the Governor of Sierra Leone, would leave for England on Monday, Captain Hay had gone from Bathurst to take charge.

THE EASTERN AND SOUTH AFRICAN TELEGRAPH COMPANY.—This company notify that the coupons on their Five per Cent. Mortgage Debentures due on 1st July will be paid on and after that date by Messrs. Barclay, Bevan, and Co., Lombard-street, London, E.C. Coupons must be left three clear days for examination.

EXAMINERS IN ELECTRICITY.—At the recent examination of the London University for the degree of Doctor of Science in the subject of electricity the candidates were asked to describe "Wilmshurst's influencing (*sic*) machine." We have heard of influence machines, and we have the honour of knowing Mr. Wimshurst, but what is this new horror?

SMALL INDUSTRIES EXHIBITION, STOCKHOLM.—Group IV. of an exhibition to be opened at the Utställningskomiterade, Stockholm Handtverksföreningenshus, includes machines and apparatus of small size for the production and application of electricity; but no object must require more than 2 square metres of ground space, for which no rent is charged.

ELECTRICITY AND GAS COMPANIES.—A Bill will probably be favourably reported to the Massachusetts Legislature relative to the extension of the charters of the gas companies of the State permitting them to distribute electric currents. The broad powers granted will open the field of the distributing of power by electric motors, or the furnishing of currents to home railroads for the purpose of propulsion.

EASTERN EXTENSION COMPANY.—The Eastern Extension, Australasia, and China Telegraph Company states that the coupons due 1st of July on the Five per Cent. Australian Government Subsidy Debentures will be paid by Messrs. Barclay, Bevan, and Co. Coupons must be left three clear days for examination. The company announce an interim dividend for the quarter ended March 31st of 2s. 6d. per share, tax free, payable on July 15th.

VAN RYSSELBERGHE.—*Le Globe Illustrè* of June 13, an illustrated paper published at Brussels, gives a short biography of M. Van Rysselberghe, with portrait. With regard to his system of telephony upon the telegraph wires, we are told that the first official experiments were made on the 4th March, 1882, between Ostend and Brussels, and that on the 16th and 17th March the experiments were between Paris and Brussels. The system has been shown by numerous experiments to be successful.

ORIGIN OF ELECTRICITY IN STORMS.—M. Colladon, in a paper to the Academié des Science, suggests that the electricity so vividly illustrated by thunderstorms is generated principally by friction of air and water vapour. During a thunderstorm the rain drops formed in the storm cloud descend vertically to the earth, causing a partial vacuum, which is replaced by air drawn in laterally and from upper layers. The friction caused by this movement is the principal cause of the generation of electricity.

THE TYPO TELEGRAPH.—This new invention is now being tried by the French Minister des Postes et des Télégraphes, to whom it has been submitted by M. Etienne de Fedor. It is intended to devote it chiefly to press messages. The article of a journal which is to be forwarded by telegraph to another journal is first set up in ordinary type in a column and then stereotyped. The block is afterwards sent to the telegraph office, and serves as original of the message. M. Fedor claims that the rapidity of the transmission may reach about 1,200 letters per minute, or about 14,000 words per hour.

THE EASTERN TELEGRAPH COMPANY.—This Company announce that, subject to the final audit, the accounts show, after placing £70,000 to reserve fund, a balance available for dividend sufficient to pay at the general meeting on 15th July next the fixed dividend of 3s. per share, being at the rate of 6 per cent. per annum on the Preference Shares, and a final dividend of 2s. 6d. per share, with a bonus of 1s. per share, free of income tax, on the Ordinary Shares, making, with previous payments on account, a total dividend of 6 per cent. on those shares for the year ending 31st March, 1886, and carrying forward a balance of about £4,000.

ACCIDENTS FROM LIGHTNING.—Dr. Andries, having circulated that accidents from lightning have increased from three to five fold during the last 50 years, finds that the causes which have been assigned for the phenomenon do not account for all. He regards the main cause as lying in the

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enormous increase in manufactories, locomotives, &c., which fill the air with smoke, steam, and particles of dust of all kinds, while the increased populations contribute their share to the impurity of the atmosphere. His own experiments, and those of others, have shown that all the electrical phenomena of the air increase in intensity with the increase of dust in it.

ELECTRIC LIGHT IN AMERICA.—The development of electric lighting in the United States is rapid and continuous, as may be gathered from the fact that the Edison system alone comprises forty-one central stations, with a total capacity of supplying 100,000 lamps. Thirty-two of these stations are now actually at work, lighting 85,725 incandescent lamps. Adding to these the lamps to be lighted very shortly at stations now in course of construction, the total installation of Edison lamps in the United States will amount to 127,425. This is quite independent of the other systems in use. In France the total number of lamps of every kind now in operation is only 55,000.

AN ENTERPRISING HOUSE.—MM. Sautter, Lemonnier and Company have already installed in France 1,357 arc and 1,613 incandescent lamps, in addition to 288 arc and 523 incandescent lamps in foreign countries. Of these, England absorbs 88, the colonies 49, while 43 are in India, and 28 in Italy. The photo-electrical apparatus for naval and military purposes constructed by this firm is even more widely and extensively distributed, being adopted by every country in Europe, as well as by Japan and the United States. The total number of Gramme machines employed in connection with this apparatus amounts to 587, requiring a motive force equal to 3,167 horse-power.

THE ELECTRIC LIGHT AT COLCHESTER.—At a special meeting of the Colchester Town Council, held last week, the following resolution was passed:—"Resolved unanimously, that this Council hereby sanctions the transfer from the South-Eastern Electric (Brush) Lighting and Power Company to the Colchester Electric Light and Power Company, of the Colchester Electric Light License, 1884." It is to be hoped that under whatever arrangement may be come to between the old and the new company, Colchester, which was the first town in England, or, for the matter of that, in the world, that adopted the electric light for public lighting, will be better served in this respect than it seems hitherto to have been.

CABLE TO BATHURST.—We are informed by the India Rubber, Gutta Percha, and Telegraph Works Company that the cables from Sénégal, from the Cape Verd Islands and from Bolama have been successfully completed to Bathurst, and that their ships the "Dacia" and "Buccaneer" have left that place for Siérra Leone to complete the Konakri-Siérra Leone section. The West African Telegraph Company's station at Bathurst has been opened to the public, and messages can now be sent to that place, addressed, *viâ* Cadiz, from the offices of the Direct Spanish Telegraph Company, the Eastern Telegraph Company, and the Submarine Telegraph Company, or from any postal telegraph station, the tariff being 5s. 11d. per word. This important advantage will be, we doubt not, highly appreciated by the telegraphing public.

SENDING PICTURES BY TELEGRAPH.—The *British Journal of Photography* mentions the fact that a patent for sending pictures by the telegraph wire has recently been taken out. Photography is an essential in the process. Mr. Grimnill, of Kirkmaiden, Wigton, has patented a system of photo-telegraphy, of which the following is a description: The picture is projected in sections, as it were, upon selenium cell in the circuit of the wires, and so causes a greater or less number of subsidiary currents to be switched on to an incandescent lamp at the receiving end, the brightness of the light following the intensity of the spot of picture thrown upon the selenium. Here the photography is of service. The lamp is focused on to a plate, and its varying intensities fixed upon the photographic tablet. The idea may be very good; but it displays more ingenuity than practicability.

NORTHERN DISTRICT TELEPHONE COMPANY.—This company, who have been doing some good work in the Newcastle district during the past six months, have now completed the chain of trunk wires connecting Darlington with Newcastle and Tyneside. The following towns are now in communication:—Newcastle, Sunderland, Tyne Dock, Jarrow, Gateshead, South Shields, East and West Hartlepool, Stockton, Middlesbrough, and Darlington. A very perfect system has been completed, which will be further improved when Durham and Auckland are added to the list. We may state that the excellent arrangements of the Darlington Exchange have been carried out under the personal supervision of Mr. H. A. Henderson, the local engineer to the company, while the trunk wires have been erected by Mr. G. F. L. Preston and Mr. C. F. Bailey, the engineers respectively at Stockton and Hartlepool.

WATER COLOURS AND THE ELECTRIC LIGHT.—In an article on "Light and Water Colours," contributed to the June number of the *Nineteenth Century* by J. C. Robinson, the following passage occurs: "The action of the electric light on water colour pigments is a question of much interest, and it is greatly to be desired that some competent scientific authority should practically investigate it. The feasibility of the exhibition of water colour drawings in our public collections literally depends upon a favourable solution of this question, for nothing is more certain than that the continuous exhibition of water colour drawings of past epochs by daylight inevitably entails their rapid, irremediable, and more or less complete and final deterioration. It is not unlikely that the white or bluish 'arc' light would, though in a far less degree, be as destructive as the sun's light to mutable pigments; but the yellow 'incandescent' light, on the contrary, would probably be found to exercise no perceptible bleaching influence."

TELEGRAPHIC COMMUNICATION.—"J. E. K." writes to *The Times*:—"If I might generalise from a single district I should say that the state of our telegraphic communications calls for immediate and serious attention. A complaint which I made to the West District office in Vere-street has brought to my knowledge the fact that the number of blunders which draw forth similar complaints to that office alone amounts to 30 or 40 a day. Possibly some of these may be attributable to the senders—mine was not; but to set against this we must take into account those about which the offices hear nothing. Telegraphic communications are for the most part about matters of more than ordinary importance, and such as need more than common expedition; but if addresses containing three figures, say 184, are wired with only one (8), what chance is there of the message reaching its destination within any time upon which the sender can reasonably calculate? This is one specimen of the variety of blunders to which we shall continue to be liable until greater care is exercised, and more efficient agents are employed."

DISASTROUS THUNDERSTORMS.—On Saturday last one man was killed and several persons injured by lightning at Wigan. The thunderstorm broke over the town, and lightning struck a party of spectators surrounding a booth outside the public park. Seven persons were thrown down, and it was found that one was dead and two others partially paralysed. The lightning was very vivid and the thunder was extraordinarily loud. At Golborne the church tower was stripped of its slates, and some narrow

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escapes are reported. A severe thunderstorm broke over South Dorset in the evening, and was accompanied by a tremendous fall of hailstones. Considerable damage has been done to the growing crops.—A very severe thunderstorm broke over Christchurch about six o'clock in the evening, and during its rage it did damage to the Priory Church; the vane, which was erected in 1659, being struck by the electric fluid, and the massive oak post upon which it was fixed split into pieces. The roof of the old tower, 120ft. high, was also considerably damaged. Many of the pieces of oak were carried into Colonel Tighe's grounds at some distance from the church, but, fortunately, no one was injured.

TAMPERING WITH TELEGRAPH MESSENGERS.—An important prosecution under the Telegraph Act was heard at the Bradford Borough Court on Tuesday. Emmanuel Eastwood was charged with inciting a telegraph messenger to wilfully delay a message. It was stated by the police that his object in delaying messages was to make fraudulent bets. He was in receipt of telegrams respecting races himself, and on several occasions he had met messengers on their way to Morgan's News Rooms in Kirkgate, where the results of races are posted, and endeavoured to delay the delivery of the messages in order that he might have time to take fraudulent advantage of his own information. The specific charge was committed on the 14th inst., when he met a messenger, and offered him 3d. to "play about" with his message. Two other messengers gave evidence as to the prisoner attempting to induce them to delay the delivery of the messages. The case had been reported to the Postal Department, who would probably take it up also. Prisoner, in answer to the charge, denied that he had interfered with the messengers in the manner alleged. He had simply told them to "hurry up" with his own private messages. Prisoner was committed to the Sessions for trial.

INCANDESCENT LAMPS IN MINES.—An interesting application of the electric incandescent light to mining recently took place at Lord Vernon's Poynton and Worth Colliery, near Stockport. It appears that the lower pump rod of the main pumping shaft of the Lady Pit, by which the pits are drained, broke, leaving the bucket in the bottom some 600ft. below, and submerged in water. To remedy the rupture divers were employed from the firm of Siebe, Gorman, and Co, the well known submarine engineers, of Westminster, and their operations were carried on by the light of a Siebe diver's electric lantern, worked by Thame's primary battery. The barrel of the shaft was disjointed and pulled up, and the pump rod was repaired by this means. The Siebe lantern is a strong appliance, and weighs some 83lbs. out of water. It consists of an iron cover permitting the conductors to pass inside to a cluster of four incandescent lamps, the light of which is reflected downwards by a white reflector in the roof. A stout glass globe encircles these, and is protected from injury by iron prongs around it. Fifteen cells of Thame's primary battery were employed, and the total light obtained was about 80 candles, a luminous sphere of some 6ft. in radius being obtained under water.

PROFESSOR BELL'S PATENT.—Another decision in favour of Prof. Bell has just been arrived at in the New Orleans suit, Judges Parder and Billings confirming all the prior decisions obtained in the American courts as to the validity of his patents. The Court has decided that the ground, if not the principal ground, of defence in the action, namely, that the invention of Bell lacked novelty because it had been anticipated by Philip Reis, has not been made out. It admits that Reis made great strides towards "the discovery of the great fact or law" announced in Bell's fifth claim, but added that the fact that he failed to reach it was equally beyond doubt. It was, moreover, in the opinion of the Court overwhelmingly established that Bell made the affidavit to his claim and specifications as originally filed on the 26th of January, 1876, while Gray's description of his invention embodied in his caveat was not written out till three or four days prior to February 4, when it was filed. The judges said, in conclusion, that from the evidence submitted in the case it seemed clear, in the present stage of telephony, that neither the Reis instruments nor any reproduction of them could be made to transmit articulate speech, "except by changes of some form in the instruments themselves or by the employment of Bell's method." The whole interest of the telephone controversy centres now in the case of Prof. Elisha Gray; and the Government, it is said, is meantime collecting evidence abroad to be used in its suit to annul the Bell patent.

GAS WELLS FIRED BY LIGHTNING.—The burning of natural gas wells in Pennsylvania are sights as thrilling to the beholder as they are dangerous to adjacent property. We have given the particulars of these on various occasions. Recently one of these wells took fire, and a volume of flame shot up into the air for several hundred feet with a velocity that was astounding, showing that the pressure of gas from beneath was something beyond comprehension. This well burned for a long time in spite of all efforts to shut off the flame. It was finally done by means of a huge extinguisher, which was advanced slowly to the mouth of the well, and then raised vertically, thus shutting off the air and smothering the flame. A few days since, one of these wells was set on fire in a very curious manner. The workmen had drilled down until gas in small quantities was found to arise through the boring. A sudden storm came up, the atmosphere became thick and prevented the gas from rising freely. The workmen anticipated trouble, and hastily departed from the well. They had scarcely get to a safe distance when a flash of lightning ignited the gas in the atmosphere over the well; flames instantly communicated to the well itself, the result being that the gas in the lower regions was released, and shot upward with a terrific flame to a height of 200ft. or more. The well burned for several days, the column of flaming gas mounting into the air and lighting up the surrounding country for miles. Another well was struck at the same time in another section of the oil regions, and was burning for a long time, threatening adjacent property. Fires occurring in the products of the oil regions, whether gas or oil, are extremely difficult to extinguish, and the amount of property lost in consequence of them is immense.—*Fireman's Journal.*

ELECTRIC STREET CARS IN PHILADELPHIA.—The Union Electric Company has recently been operating an experimental electric motor car on Ridge Ave., between 32nd and 33rd Streets, Philadelphia, and has met with very fair success. Each afternoon a car, carrying the usual burden of passengers, has been run over the track at the rate of nine miles an hour. The system employed is that of underground electrical transmission. A conduit, 4½in. wide by 9in. deep, and having a central slot similar to that employed on cable roads, extends along the centre of the track. This has been laid on concrete, and covered with Portland cement. At suitable intervals, connections are made with the sewer, in order to permit the rain water to discharge or the conduit to be washed out, should that become necessary. A copper conductor, one-quarter inch deep by one inch wide, runs along the conduit on each side of the slot. A grooved piece of channel iron is attached to the bottom of the conductors. A so-called "traveller," supported by wheels,

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runs in the slot, and is provided with two springs which slide along the channel irons on each side of the slot, and thus receive the electric current. The traveller is connected to the car by small chains. From its centre wires extend into the car, connecting the motor on board with the copper conductors in the conduit, by which the electric circuit may be closed. A regulator on the car controls the current, and permits the car to be driven in either direction. The trials covered a very stormy period, but it is stated that the bad weather caused no interruption in the working of the system. The estimated cost per day of running the electric car, according to the *Ledger*, is $1·84, while that of operating a horse car is $4·74. Neither estimate includes salaries. The cost of ten miles of electric railway on this system, and fifty cars, is stated to be $175,000.

THE ELECTRIC LIGHT IN THE TEMPLE.—On the occasion of the visit of Princess Louise to the Temple Church on Saturday, to celebrate the fiftieth anniversary of the reign of her Royal mother, not the least interesting episode was the illumination of the sacred edifice by the electric light. The installation altogether consisted of sixty-two incandescent lamps attached to fourteen electroliers of hand-wrought iron of simple and chaste design, ten of which contained five burners and four of them three burners. The brass candelabra were all removed, greatly improving the effect, and giving the impression that the edifice was enlarged. The light was also introduced with great success into the Parliamentary Chamber, the reception rooms, and the Hall. In the latter a temporised stage was fitted up, under the superintendence of Mr. Henry Irving, for the representation of the "Midsummer Night's Dream," the principal characters of which were assumed by barristers and benchers of the Temple. A number of incandescent lamps were placed immediately above the stage curtains, and others did duty as footlights, their effect on the tapestry and floral decorations evoking the greatest admiration on the part of the Royal and other visitors. At the back of the stage there was a marble bust of Her Majesty, adorned with a floral wreath of quite a new material in the way of decorative art, resembling biscuit china, but which in reality was plaster of paris ornamentature, reproducing by means of electricity from natural ivy and laurel leaves exact replicas of the real foliage in plaster. Amongst these artificial wreaths some lamps were tastefully distributed, producing a most pleasing effect. In the Parliamentary Chamber there was also a bust of the Princess Louise, placed on a pedestal surrounded by flowers, in the midst of which a few lamps were arranged in such a manner that the effect of their light on the marble figure was the same as if it had been visited by a glimpse of the afternoon sun. Outside the building a very powerful arc lamp was put up, and was fed by the incandescent leads without the usual resistance apparatus employed to prevent the incandescent lamps pulsating, and gave out a brilliant light of remarkable steadiness. Throughout the evening the lamps were run at their nominal candle-power, and were pronounced an emphatic triumph for the electric light. The work was carried out by Messrs. Mortimer and Shepherd, and the effective manner in which it was done redounds to the credit of the firm; in fact, we should not be surprised to find that the system adopted to beautify the scene in this case was extensively followed hereafter.

COLONIAL AND INDIAN EXHIBITION.—At the Conference on Wednesday, June 23rd, a paper was read by Mr. W. Lant Carpenter on "The Position of Science in Colonial Education." The colonies to which Mr. Carpenter had directed his attention were:—Canada generally; in South Africa, the Cape of Good Hope and Natal; Western and South Australia, Victoria, New South Wales, Queensland, New Zealand, and Tasmania, the last of which, unfortunately, was not represented at the present Exhibition. An account of the present condition of scientific education in each of these colonies was given. As a general conclusion, Mr. Carpenter thought that the claims of science to a place in State-aided primary education were more fully recognised than in the old country, and this, not merely because it was the only foundation upon which a system of technological education could be securely built, but for its value in drawing out the minds of the pupils. As regards the branches by which the time-honoured routine of subjects may be most beneficially varied, precedence was almost universally accorded to drawing, and to the objective presentation of the elements of science. In secondary grammar and high schools, however, science scarcely occupied a position equal to that in corresponding English schools, but there were many signs of improvement in this respect. In the colleges and universities of the older colonies, the classical and academic influence was still very strong, while in the newer ones the claims of scientific education to be put on an equal footing with literary were recognised. Great as had been the progress of public opinion in England during the last few years on the importance of science as an element in education, the author was disposed to consider it greater in the colonies in the same period. Certainly the development of that opinion to its present point had been much more rapid in the colonies than at home. There were many voluntary colonial associations for the promotion of science, and the author concluded his paper by throwing out the suggestion that, if there were grave and practical difficulties in the way of an Imperial federation of the Australian colonies, the establishment of an Australian association for the advancement of science, somewhat on the lines of the British and American associations for similar purposes, might not be beyond the reach of practical scientists, and he was strongly of opinion that such a federation would tend to strengthen "the position of science in colonial education."

PRIMARY BATTERIES.—We have again to utter a word of warning against the many attempts which are being made to force upon the confiding public primary batteries for electric lighting purposes. It is only under exceptional circumstances that a primary battery can be used for such a purpose, and it may be at once stated that whenever used it must be looked upon more as a luxury than as a part of ordinary everyday commercial work. We are led to make these remarks from a notice which appears in an Indian contemporary to the following effect: "Numerous attempts have been made to obtain a successful incandescent electric light by means of secondary storage batteries, charged from dynamos; but, owing to the small amount of electricity obtained in comparison with the power required, these batteries have so far, we believe, not been proved to be a commercial success. One of the latest improvements in this direction has been the production of a primary battery, named the 'Aurora,' which is really an improved bichromate solution battery, having a power which is remarkable for its size, and the advantage of not polarising, heating, or evolving any deleterious gases. Each cell holds about a gallon of the exciting fluid, which, we are informed, is made by a peculiar patented process, and is the important factor in the success of the battery. Two large carbon plates are placed outside of the porous cup, and in the latter is inserted the zinc, of a special form to expose a large amount of surface. In the porous cup is put water, which in a few hours becomes charged with the exciting fluid from the outside of the jar. The zincs are

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well amalgamated to prevent local action." We shall probably have a good deal to say upon this question of primary batteries in the near future, inasmuch as at the present time two primary batteries are being brought to the attention of the English public. One of these, the Lalande battery, has been tried carefully and upon a practical scale. The idea of the owners of this battery is to increase their income by the manufacturing and the sale of what may be termed "bye products." In this, following the example of the gas companies, they take all the trouble of seeing to the batteries, emptying and renewing the liquid, &c., upon their own shoulders, the user having no more trouble than he has in the case of gas. Then Messrs. Woodhouse and Rawson are bringing forward the Upward battery, which is said to be an entirely new departure to give good results—and little trouble to the user. Chlorine gas acting upon zinc is the source of the energy in this battery.

LONDON CHAMBER OF COMMERCE.—A Congress of Chambers of Commerce of the British Empire will be held (by special permission of H.R.H. the Prince of Wales), in the Conference Room of the Colonial and Indian Exhibition, South Kensington, on Tuesday and Wednesday, July 6 and 7, from 10 a.m. to 4 p.m. The following Chambers of Commerce or Commercial Associations have signified their intention of taking part in the Congress:—Barrow-in-Furness, Barnsley, Batley, Birmingham, Bradford, Bristol, Cardiff, Cleckheaton, Derby, Dewsbury, Dudley, Exeter, Falmouth, Gloucester, Halifax, Heckmondwike, Huddersfield, Hull, Kendal, Kidderminster, Leeds, Liverpool, Llanelly, Luton, Macclesfield, Middlesborough, Morley, Newark-on-Trent, North Shields, Newcastle-on-Tyne, Newport (Mon.), Nottingham, Oldham, Ossett, Plymouth, Portsmouth, Sheffield, Southampton, Stockton-on-Tees, Sunderland, Swansea, Wakefield, Walsall, Warrington, Wolverhampton, Worcester, Aberdeen, Dundee, Greenock, Leith, South of Scotland, Belfast and Dublin, Jersey; the Chamber of Manufacturers of Adelaide, and the Chambers of Commerce of Adelaide, Auckland, Christchurch, Dunedin, Suva (Fiji), Hobart, Invercargill, Launceston, Maryborough, Melbourne, Napier, Nelson, Sydney, and Wellington; the Boards of Trade of Toronto, Montreal, Quebec, and Hamilton; the Chamber of Commerce of Hong Kong, the Chambers of Commerce of Bombay, Bengal (Calcutta), Colombo (Ceylon), and Madras; the Chambers of Commerce of Rangoon (British Burmah), and Singapore; the Chambers of Commerce of Cape Town, Durban, Mossal Bay, and Port Elizabeth; the Royal Agricultural and Commercial Society, British Guiana; the Chambers of Commerce of Barbadoes, Jamaica, and Trinidad; British Chamber of Commerce in Paris. Among the questions for discussion is that of postal and telegraphic reform, which will consider the possibility of an Anglo-Colonial Penny Postal Union; extension of the telegraph system; reduction of rates; neutralisation of cables, &c. Opener:—For postal matters, J. F. Hutton, Esq., M.P.; for telegraphic matters, John Pender, Esq. The following resolution will be proposed:—That the reduction of the Anglo-Indian and Colonial postal and telegraph charges, and the neutralisation of cables, be commended to Her Majesty's Government and to the Governments of the various Colonies as desirable in the interests of the Empire and of international commerce; and this Congress strongly urges upon Her Majesty's Government to advance such objects, when possible, by international treaty, and by inviting the joint action of the Colonial and Indian Governments thereon. In this view the Congress particularly points to the desirability of the assimilation of the Colonial and Indian postal tariffs to those of the International Postal Union.

TELEPHONIC STATISTICS.—The following is a continuation from our last issue of M. Rothen's telephonic statistics:—

New Zealand.

Towns.	No. of Subscribers.	Population.	Population per Subscriber.	No. of daily calls per Subscriber.
Dunedin	343	43,846	128	8·1
Auckland	320	34,088	106	5·6
Wellington	204	22,825	112	9·25
Christchurch	184	32,915	179	10·2
Invercargill	41	9,350	228	4·4
Nelson	39	7,287	178	4·0
Oamaru	33	6,587	200	2·5

This information is brought up to the 30th April, 1885. All the exchanges are in the hands of the Government. The subscription varies from 200fr. to 250fr. It is 225fr. for the first 100 subscribers to a new exchange for the first year, and 200fr. for following years. The maximum distances is for houses of business, 800 metres; for private houses, 1,600 metres; for every 400 metres additional distance they pay in the first year 25fr. and for succeeding years 19fr. The subscribers who subscribe after the opening of an exchange pay in the first year 250fr., and in the following years 200fr. A second communication costs 175fr. There are in all the exchanges a total of 22 public rooms. Up to the 31st December, 1884, the total expenses for the construction of the exchanges amounted to 660,895fr. The preliminary maintenance and repairing expenses amounted to 141,170fr., and the receipts to 241,000fr. There are besides the exchanges mentioned 110 telegraphic offices furnished with telephonic appliances.

Inter-Urban Communication.

The second period in telegraphic progress is that introducing and developing the interconnection of towns telephonically. Up to the time these statistics were compiled the following interconnections had been completed. The approximate distance in miles is given within parentheses:—

Austro-Hungary.

Gleichenberg–Gablonz (12½).

Belgium.

Bruxelles–Anvers.
Bruxelles–Gand.
Bruxelles–Louvain.
Bruxelles–Liége.
Bruxelles–Charleroi.

This connection works by the Van Rysselberghe system.

France.

Lille–Roubaix–Tourcoing.
Elbœuf–Louviers.
Paris–Reims (110).
Rouen–le Havre.

Between Paris and Reims and Rouen and Havre the Van Rysselberghe system is in operation.

Great Britain.

London-Brighton.
Accrington-Ashton-Blackburn-Blackpool-Bolton-Burnley-Bury-Derven-Heywood-Liverpool.
Manchester-Salford.
Middleton-Oldham-Preston-Radcliffe-Rochdale-Runcorn-Widnes-St. Helens-Southport-Stalybridge-Stockport-Warrington-Wigan.
Sunderland-South Shields-Newcastle-North Shields.
Dundee and Forfar-Perth-Arbroath.
Tynedock-Yarrow-Newcastle.
Glasgow-Edinburgh-Greenock-Paisley-Coatbridge-Dumbarton-Hamilton.
Bradford-Leeds-Huddersfield-Halifax-Dewsbury-Wakefield-Sheffield.
Birmingham-Wolverhampton-Wednesbury.
Nottingham-Loughborough-Long Eaton-Basford-Ilkeston.
Whitehaven-Workington-Maryport.
Wingate Colliery-Hartlepool (12).
Sunderland-Hartlepool.
Cardiff-Newport.
Keighley-Bradford.
Belfast-Augusta.

United States of America.

Kansas City–St. Louis (320).
Milwaukee–Oskosh (175).
Boston–Portland (116).
Worcester–Springfield (99).
Madison–Milwaukee (87).
Chicago-Elgin (62).
Tremon–Columbus (49).
Boston–Worcester (45).

Besides these communications there are a great many others, as to which we have not been able to obtain accurate information.

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ELECTROMAGNETIC INDUCTION AND ITS PROPAGATION.—XXVIII.

BY OLIVER HEAVISIDE.

(Continued from page 89.)

Some Special Results Relating to the Rise of the Current in a Wire.

Premising that the wire is of radius a_1, conductivity k_1, inductivity μ_1; that the dielectric displacement outside is ignored; and that the sheath for the return current is at distance a_2, and is so thin that variations of current density in it may be ignored, so that merely the total return current need be considered; that a_4 is the small thickness of the sheath, and k_3 its conductivity, we have the determinantal equation (30*b*). Let now

$$L_0 = 2\mu_2 \log(a_2/a_1), \quad R_1 = (k_1 \pi a_1^2)^{-1}, \quad R_2 = (2\pi a_2 a_4 k_3)^{-1}.$$

L_0 is the external inductance per unit length, *i.e.*, the inductance per unit length of *surface* current, ignoring the internal magnetic field. R_1 and R_2 are the resistances per unit length of the wire and sheath respectively, and $\frac{1}{2}\mu_1$ is the internal inductance per unit length, *i.e.*, the inductance per unit length of uniformly distributed wire current when the return current is on its surface, thus cancelling the external magnetic field. We can now write (30*b*) thus:—

$$J_0(n_1a_1) = J_1(n_1a_1)\{\tfrac{1}{2}n_1a_1(L_0/\mu_1) - (\tfrac{1}{2}n_1a_1)^{-1}(R_2/R_1)\}; \quad . \quad (31b)$$

and, in this, we have

$$\left.\begin{aligned} -n_1^2 a_1^2 &= 4\pi\mu_1 k_1 p a_1^2 = 4p\mu_1/R_1, \\ J_0(n_1a_1) &= 1 - \frac{n_1^2a_1^2}{2^2} + \frac{n_1^4a_1^4}{2^2 4^2} - \ldots, \\ J_1(n_1a_1) &= \tfrac{1}{2}n_1a_1\left(1 - \tfrac{1}{2}\frac{n_1^2a_1^2}{2^2} + \tfrac{1}{3}\frac{n_1^4a_1^4}{2^2 4^2} - \ldots\right). \end{aligned}\right\} (32b)$$

From (31*b*) we see that the two important quantities are the ratio of the external to the internal inductance, and the ratio of the external to the internal resistance, *i.e.*, the ratios L_0/μ_1 and R_2/R_1.

Suppose, first, the return has no resistance. Draw the curves $y_1 = J_0(x)/J_1(x)$ and $y_2 = \frac{1}{2}(L_0/\mu_1)x$, the ordinates y, abscissæ x, which stands for n_1a_1. Their intersections show the required values of x. The J_0/J_1 curve is something like the curve of cotangent. If L_0/μ_1 is large, the first intersection occurs with a small value of x, so small that $J_0(x)$ is very little less than unity, so that a uniform distribution of current is nearly represented by the first normal distribution, whose time constant is a little greater than that of the linear theory. The remaining intersections will be nearly given by $J_1(x) = 0$. On the other hand, decreasing L_0/μ_1 increases the value of the first x; in the limit it will be the first root of $J_0(x) = 0$. Thus, if the wire be of copper, and the return distant (compared with radius of wire), the linear theory is approximated to. If of iron, on the other hand, it is not practicable to have the return sufficiently distant, on account of the large value of μ_1, unless the wire be exceedingly fine. Even if of copper, bringing the return closer has the same effect of rendering the first normal system widely different from representing a uniform distribution of current. It is the external magnetic field that gives stability, and reduces differences of current density.

Next, let the return have resistance. The curve y_2 must now be $y_2 = \frac{1}{2}(L_0/\mu_1)x - 2(R_2/R_1x)$. The effect of increasing R_2 from zero is the opposite of that of increasing L_0. It increases the first x, and tends to increase it up to that given by $J_1(x) = 0$, (not counting the zero root of this equation). Thus there is a double effect produced. Whilst on the one hand the rapidity of subsidence is increased by the resistance of the sheath, on the other the wire current in subsiding is made to depart more from the linear theory uniform distribution. The physical explanation is, that as the external field in the case of sheath of no resistance cannot dissipate its energy in the sheath it must go to the wire. But when the sheath has great resistance the external field is killed by it; then the internal field is self-contained, or the wire current subsides as if $J_1(x) = 0$, with a wide departure from uniform distribution. This must be marked when the wire circuit is suddenly interrupted, making the return resistance infinite.

Now, let there be no current at the time $t = 0$, when put on, and keep on, a steady impressed force, of such strength that the final current density in the wire is Γ_0. At time t the current density Γ at distance r from the axis is given by

$$\Gamma = \Gamma_0\left[1 - \Sigma\frac{2}{n_1a_1}\frac{(R_1+R_2)J_0(n_1r_1)/J_1(n_1a_1)R_1}{1 - R_2/\mu_1 p + \{J_0(n_1a_1)/J_1(n_1a_1)\}^2}\epsilon^{pt}\right]$$

where the n_1a_1's are the roots of equation (31*b*). And the total current in the wire, say C_1, and with it the equal and opposite sheath current will rise thus to the final value C_0,

$$C = C_0\left[1 - \Sigma\frac{4}{n_1^2a_1^2}\frac{(R_1+R_2)\epsilon^{pt}/R_1}{1 - R_2/\mu_1 p + \{J_0(n_1a_1)/J_1(n_1a_1)\}^2}\right]$$

It will give remarkably different results according as we take the resistance of the wire very small and that of the sheath great, or conversely, or as we vary the ratio L_0/μ_1. Infinite conductivity shuts out the current from the wire altogether, and so does infinite inductivity; the retardation to the inward transmission of the current being proportional to the product $\mu_1k_1a_1^2$. Similarly, if the sheath has no resistance, the return current is shut out from it. In either of these shutting out cases the current becomes a mere surface current, what it always is in the initial stage, or when we cannot get beyond the initial stage, by reason of rapidly reversing the impressed force, when the current will be oppositely directed in concentric layers, decreasing in strength with great rapidity as we pass inward from the boundary. But if both the sheath and the wire have no resistance, there will be no current at all, except the dielectric current, which is here ignored, and the two surface currents.

The way the current rises in the wire, at its boundary and at its centre, is illustrated in "Induction in Cores." For the characteristic equation of the longitudinal magnetic force in a core placed within a long solenoid, and that of the longitudinal current in our present case, are identical. The boundary equations are also identical. That is, (31*b*) is the boundary equation of the magnetic force in the core, excepting that the constants L_0/μ_1 and R_2/R_1 have entirely different meanings, depending upon the number of turns of wire in the coil, and its dimensions, and resistance. If, then, we adjust the constants to be equal in both cases, it follows that when any varying impressed force acts in the circuit of the wire and sheath, the current in the wire will be made to vary in identically the same manner as the magnetic force in the core, at a corresponding distance from the axis, when a similarly varying impressed force acts in the coil circuit (which, however, must have only resistance in circuit with it, not external self-induction as well). Thus, we can translate our core solutions into round straight wire solutions, and save the trouble of independent investigation, in case a detailed solution has been already arrived at in either case.

Refer to Fig. 3, p. 387, *The Electrician*, September 6, 1884. It represents the curves of subsidence from the steady state. The "arrival" curves are got by perversion and inversion, *i.e.*, turn the figure upside down and look at it from behind. The case we now refer to is when the sheath has negligible resistance, and when we take the constant $L_0 = 2\mu_1$, which requires a near return when the wire is of copper, but a very distant one if it is iron.

Regarding them as arrival curves, the curve h_1h_1 is the linear theory curve, showing how the current density would rise in all parts of the wire if it followed the ordinarily assumed law (so nearly true in common fine wire coils).

The curve H_aH_a shows what it really becomes, at the boundary, and near to it. The current rises much more rapidly there, in the first part of the variable period, and much more slowly in the later part. From this we may conclude that, when very rapid reversals are sent, the amplitude of the boundary current density will be far greater than according to the linear theory; whereas if they be made much slower it may become weaker. This is also verified by the separate calculation in "Induction in Cores" of the reaction on the coil current of the core currents when the impressed force is simple harmonic, the amplitude of the coil current being lowered at a low speed, and greatly increased at high speeds. (*Electrician*, June 14, 1884.)

The curve H_0H_0 shows how the current rises at the axis of the wire. It is very far more slowly than at the boundary.

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But the important characteristic is the preliminary retardation. For an appreciable interval of time, while the boundary current has reached a considerable fraction of its final strength, the central current is infinitesimal. In fact the theory is similar to that of the submarine cable; when a battery is put on at one end, there is only infinitesimal current at the far end for a certain time, after which comes a rapid rise.

Between the axis and the boundary the curves are intermediate between H_aH_a at the boundary and H_0H_0 at the axis, there being preliminary retardation in all, which is zero at the boundary, a maximum at the axis. It is easy to understand, from the existence of this practically dead period, how infinitesimally small the axial current can be, compared with the boundary current, when very rapid reversals are sent. The formulæ will follow.

The fourth curve h_0l_0 shows the way the current rises at the axis when the return has no resistance, but when at the same time there is no external magnetic field, or $L_0'/\mu_1 = 0$. The return must fit closely over the wire. We may approximate to this by using an iron wire and a close-fitting copper sheath of much lower resistance. There is preliminary retardation, after which the current rises far more rapidly than when L_0/μ_1 is finite.

That is, the effect of changing L_0'/μ_1 from the value 2 to the value 0 is to change the axial arrival curve from H_0H_0 to h_0h_0. Suppose it is a copper wire. Then $L_0 = 2$ means $\log(a_2/a_1) = 1$, or $a_2/a_1 = 2{\cdot}718$. Thus, removing the sheath from contact to a distance equal to 2·7 times the radius of the wire alters the axial arrival curve from h_0l_0 to H_0H_0. Now this great alteration does not signify an increased departure from the linear theory (equal current density over all the wire). It is exactly the reverse. We have increased the magnetic energy by adding the external field, and, therefore, make the current rise more slowly. But the shape of the curve H_0H_0, if the horizontal (time) scale be suitably altered, will approximate more closely to the linear theory curve h_1h_1. By taking the sheath further and further away, continuously increasing the slowness of rise of the current, we (altering the scale) approximate as nearly as we please to the linear theory curve, and gradually wipe out the preliminary axial retardation, and make the current rise nearly uniformly all over the section of the wire, except at the first moment. In fact we have to distinguish between the absolute and the relative. When the sheath is most distant the current rises the most slowly, but also the most regularly. On the other hand, when the sheath is nearest, and the current rises most rapidly, it does so with the greatest possible departure from uniformity of distribution.

If the wire is of iron, say $\mu_1 = 200$, the distance to which the sheath would have to be moved would be impracticably great, so that, except in an iron wire of very low inductivity, or of exceedingly small radius, we cannot get the current to rise according to the linear theory.

The simple harmonic solutions I must leave to another section. We may, however, here notice the water-pipe analogy (*The Electrician*, July 12, 1884). The current starts in the wire in the same manner as water starts into motion in a pipe, when it is acted upon by a longitudinal dragging force applied to its boundary. Let the water be at rest in the first place. Then, by applying tangential force of uniform amount per unit area of the boundary we drag the outermost layer into motion instantly; it, by the internal friction, sets the next layer moving, and so on, up to the centre. The final state will be one of steady motion resisted by surface friction, and kept up by surface force.

The analogy is useful in two ways. First, because any one can form an idea of this communication of motion into the mass of water from its boundary, as it takes place so slowly, and is an everyday fact in one form or another; also, it enables us to readily perceive the manner of propagation of waves of current into wires, when a rapidly varying impressed force acts in the circuit, and the rapid decrease in the amplitude of these waves from the boundary inward.

Next, it is useful in illustrating how radically wrong the analogy really is which compares the electric current in a wire to the current of water in a pipe and impressed E.M.F. to bodily acting impressed force on the water. For we have to apply the force to the boundary of the water, not to the water itself in mass, to make it start into motion so that its velocity can be compared with the electric current density.

The inertia, in the electromagnetic case, is that of the magnetic field, not of the electricity, which, the more it is searched for, the more unsubstantial it becomes. It may perhaps be abolished altogether when we have a really good mechanical theory to work with, of a sufficiently simple nature to be generally understood and appreciated.

In our fundamental equations of motion

$$\text{curl}\,(e - \mathrm{E}) = \mu\dot{\mathrm{H}}\,; \qquad \text{curl}\,\mathrm{H} = 4\pi\Gamma,$$

suppose we have, in the first place, no electric or magnetic energy, so that $\mathrm{E} = 0$, $\mathrm{H} = 0$, everywhere, and then suddenly start an impressed force e. The initial state is

$$\mathrm{E} = 0,\ \mathrm{H} = 0\,; \qquad \text{curl}\,e = \mu\dot{\mathrm{H}}.$$

Thus the first effect of e is to set up, not electric current (for that requires there to be magnetic force), but magnetic current, or the rate of increase of the magnetic induction, and this is done, not by e, but by its rotation, and at the places of its rotation.

Now, imagine e to be uniformly distributed throughout a wire. Its rotation is zero, except on the boundary, where it is numerically e, directed perpendicularly to the axis of the wire. Thus the first effect is magnetic current on the boundary of the wire, and this is propagated inward and outward through the conductor and the dielectric respectively. Magnetic current, of course, leads to magnetic induction and electric current.

Now, in purely electromagnetic investigations relating to wires, in which we ignore dielectric displacement, we may, for purposes of calculation, transfer our impressed forces from wherever they may be in the circuit to any other part of the circuit, or distribute them uniformly, so as to get rid of difference of potential, which is much the best plan. It is well, however, to remember that this is only a dodge, similar in reason and in effect to the dodges employed in the statics and dynamics of supposed rigid bodies, shifting applied forces from their points of application to other points, completely ignoring how forces are really transmitted. The effect of an impressed force in one part of the circuit is assumed to be the same as if it were spread all round the circuit. It would be identically the same were there no dielectric displacement, but only the magnetic field in question. When, however, we enlarge the field of view, and allow the dielectric displacement, it is not permissible to shift the impressed forces in the above manner, for every special arrangement has its own special distribution of electric energy. The transfer of energy is, of course, always from the source, wherever it may be. The first effect of starting a current in a wire is the dielectric disturbance, directed in space by the wire, because it is a sink of energy where it can be dissipated. But the dielectric disturbance travels with such great speed that we may, unless the line is long, regard it as affecting the wire at a given moment equally in every part of its length; and this is substantially what we do when we ignore dielectric displacement in our electromagnetic investigations, distribute the impressed force as we please, and regard a long wire in which a current is being set up from outside as similar to a long core in a magnetising helix, when we ignore any difference in action at different distances along the core.

(To be continued.)

THE STEAM ENGINE INDICATOR.—XVIII.*

BY AMICE.

Of indicator diagrams from engines of the type shown by Fig. 44 we may now take some examples, and, firstly, a set from a semi-fixed compound engine of the type very largely used for driving small electric lighting installations. Figs. 57 and 58 are from such an engine doing about 50 indicated horse-power. The cylinders of the engine are 8·5 and 17·75 respectively, the strokes being alike. The cranks are at right angles, and there is a receiver of large size, in a

* For Art. 17, see *The Electrician* 4th June, 1886.

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position between the cylinders, and with them immediately below the smoke box, which retards loss of heat. Both cylinders are, moreover, jacketed with steam direct from the boiler.

From the high-pressure diagrams (Fig. 57) it will be seen that the steam from the boiler, at about 125lb. on the square inch, is cut off at from one-fourth to one-fifth of the stroke, the expansion line being somewhat wavy, partly the effect of the oscillation of the indicator spring and parts, and partly due to re-evaporation, which is somewhat considerable, the pressures at any point after cut off being higher than can be accounted for by any other explanation, even when the amount of steam in clearance space is considered. Exhaust takes place at 40lb. per square inch, a pressure which is fairly uniformly maintained in the receiver. This back pressure is very large,

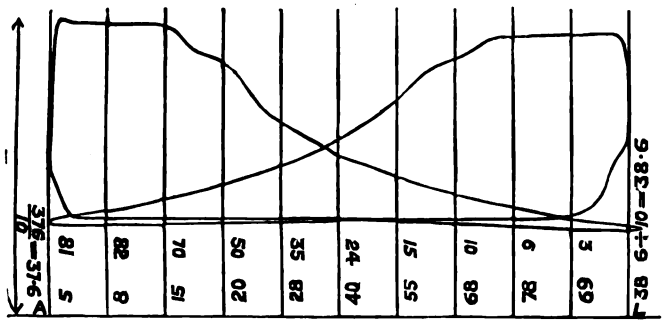

FIG. 57.

but it not only secures a much lower range of temperature in the cylinder than is common in the high-pressure cylinder, and therefore less loss by cooling of the cylinder walls, but the maximum effective pressure on the piston, about 80lb., is low enough to make it unnecessary to use the very tight piston rings which by some makers are used with high pressures. The rings and piston springs are thus more easily kept in order. The loss of pressure between the high and low pressure cylinders is shown by these diagrams to be a little over 3lb. per square inch, which is small. Steam is cut off at about one-third the stroke, expansion taking place in the low-pressure cylinder, and much less than usual in the receiver, which thus acts very much as a boiler for that cylinder. When the diagrams were taken the engine was running at about 125 revolutions per minute, driving 40 arc lamps. The mean pressures in the high-pressure cylinder, as measured and marked on the diagrams, were 37·6lbs. and 38·6lbs., giving 24·8 and 25·4 indicated horse-power in the front and back ends respectively, or a mean of 25·1 horse-power in this cylinder. The mean pressure in the low-pressure cylinder were 14·65lbs. and 15·3lbs., and 27·5 and 29·4 horse-power respectively in the front and back ends, or a mean of 28·4 horse-power. The amount of compression in either cylinder may be considered small considering the speed of the engine, but the results obtained are given by the makers, Messrs. Robey and Co., as highly economical. The mean of a number of experiments with the engine working up to 53 horse-power gave, it is stated, a water consumption of 986lbs. water and 99lbs. of coal per hour. These are exceedingly and almost phenomenally low figures for a non-condensing engine, the water consumption being but 18·6lbs. and the coal consumption only 1·86lbs. per indicated horse-power per hour.

We may now turn to a set of instructive diagrams derived, as explained, with reference to Fig. 44, from a set taken from an engine similar to that just described, and by the same makers, but of 40 nominal horse-power, instead of 20, and fitted with a condenser. Although taken with springs proportionate to the pressures in the cylinders, the two pairs of diagrams D, D′ and L, L′ have been plotted to the same vertical scale. In this form, however, they only serve as separate diagrams, showing the action of the valves, the cut-off, pressures, and the behaviour of the steam. In order to make them more correctly indicative of the performance of the engine and the steam it uses, we have reduced the horizontal scale of the high-pressure diagram by making it proportional to the relation between the areas of the high and low pressure pistons, so that the two diagrams are comparable directly, the scales being the same, and thus enabing us to see at a glance the difference between the diagram that theoretically would be obtainable from the two cylinders if acting as one non-conducting cylinder. The expansion curve C H is the curve A N reduced as described with reference to Fig. 50—that is to say, diagram D is reduced to diagram E, so as to be the same pressure and volume scale as diagram L. The continuation of that curve C H in dotted line H C is an assumed continuation at the same rate of expansion. The space F represents loss of pressure, and its area will represent work lost by reduction of pressure by cooling and frictional influences, and the spaces between low-pressure steam chest and the low-pressure cylinder, *i.e.*, the port and clearance spaces. We have in these diagrams an opportunity of making use of the methods described with reference to Figs. 36 and 38, p. 108, Vol. XVI., of ascertaining the amount of clearance, and of showing graphically the difference between the

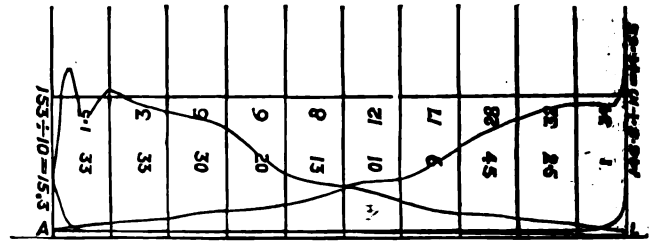

FIG. 58.

theoretical and actual behaviour of the steam in the cylinders. We will take the full diagram D. Supposing the cut-off to have taken place at A on the line C A B, as the diagram D shows, then, if the quantity of steam admitted to the cylinder were only as much as is indicated by the length of the admission line to A, the expansion line by Boyle's law would follow the dotted expansion curve A A′. The actual diagram, however, follows the line A N, which is very much

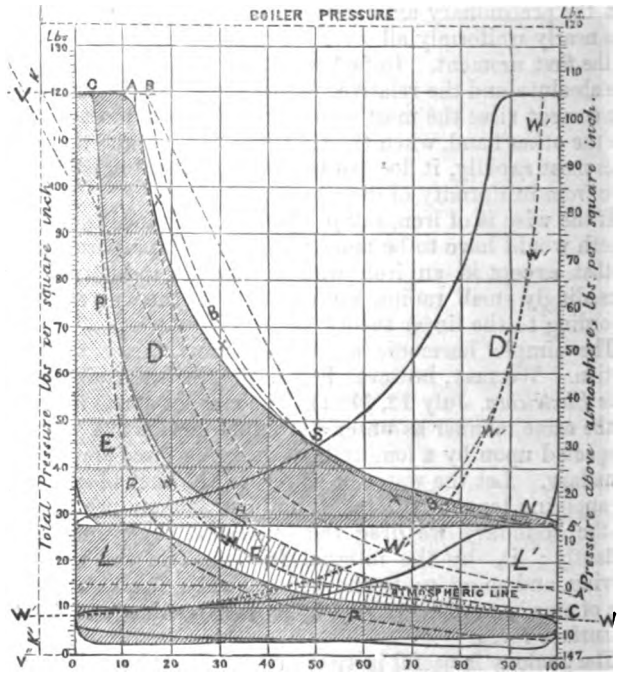

FIG. 59.

above it, showing that a great quantity of steam in excess of that indicated by the length of the admission line, assuming cut-off to have taken place at A. As there is no doubt that cut-off did take place at that point, it is clear that the port and clearance spaces and initial condensation must together be assumed to account for the quantity of steam represented by the area between the curves A N and A A′. Adopting the method described at p. 108, Vol. XVI., we will assume the clearance and port spaces to equal 7 per cent. of

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the volume of the cylinder, and draw a line K′ K to represent this volume added to that accounted for by the indicator. We may now select a point in the expansion curve whereat the expansion may be assumed to have become regular, as at S. By a vertical from this point to the line of no pressure we get the point 50, and may now get the diagonal 50 K, and parallel with it the line S B, the intersection of the admission line at B giving a length K B of admission line, which corresponds to such an expansion line as A N given by the indicator, but which would give us a true expansion line as shown by the dotted line B B B B′. As the point B is beyond the real point of cut-off A, it is obvious that more than 7 per cent. of clearance, port space, and initial condensation must be allowed for. We may find at once what this is. If we connect S and A by a line, and then draw one parallel to it from 50 we shall get the point V, showing the actual amount of steam admitted to have been 11 per cent. greater than is shown by the indicator diagram D. Knowing now the real volume of steam concerned, we may by the means already explained construct the true or theoretic expansion curve for that volume and the pressures. This we have done, and it is shown by the fine line curve A X X B′. This it will be seen is, as usual, a little higher than the indicator curve in the first part of the expansion, and below it in the latter part of the expansion or of the stroke.

Now, constructing the theoretic curve of expansion or isothermal curve for the diagram D, as reduced to the size of the part marked E, we get the curve marked C P P P, which is the theoretic expansion curve for the whole diagram, consisting of the combined high and low pressure diagrams D and L, the diagram D being reduced in scale to compare with L. This, however, does not take into consideration the 11 per cent. of clearance. Taking this in its proper proportion, remembering that the cylinders are as 3 to 1 in area, we get as the final and true expansion curve for the volume of steam employed, the curve C W W W, which for clearness we have repeated on the unshaded diagrams D′ and L′, as shown by the curve W′ W′ W′. It will be seen that the theoretic curve is coincident with the curve C H from 120lb. down to 60lb. It will be further seen that the real gap between the expansion curve of the lower diagram and the curve W W is lessened by the shaded area comprised between the letters W W H. Practice and theory thus run very close together, and if we were to make a reduction in pressure corresponding to the heat converted into work, the gap shown would really be a very small one indeed.

It should have been mentioned that the dotted line at the heel of the high-pressure curve represents the compression reduced to the scale by which C H is produced.

The engine from which the originals of these diagrams was taken has cylinders 12 and 21 miles in diameter, the stroke is 2ft., the revolutions 90, and the horse-power indicated 90. It is briefly described in the *Proceedings* of the Institution of Mechanical Engineers for August, 1885.

It will be noticed that the highest pressure in the low-pressure diagram is shown the same as the exhaust in the high pressure. This we must assume to be due to the influence of the heated receiver.

A NEW DAMPING APPARATUS.

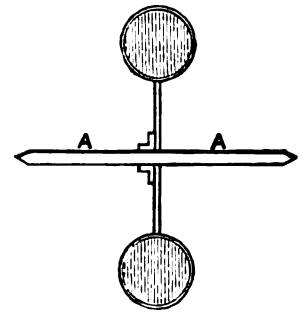
The essential principles of the damping used to still vibrations are of two kinds:—1st, the electric induction of currents in conductors; 2nd, the friction caused by the relative motion of solids and fluids.

To the second class belong vanes moving in air or water.

The scientific investigation of the friction between fluid and solid bodies has often been carried out by means of a hollow ball, set to oscillate when filled with a fluid. The friction of the fluid on the inner wall of the hollow ball itself damps the oscillation.

Dr. Frölich has investigated the question as to what form the hollow vessel should have, so as to make this damping of the vibrations as great as possible, and has found that the best form is a hollow ring rotating round its axis (as shown in section in the figure, where the ring is supposed perpendicular to plane of paper). The ring should be well paraffined inside, filled with water, and closed by soldering.

Such rings can be placed on all instruments for measuring by oscillation, and give a damping whose strength is sufficient for practical purposes, and is unchangeable with time. The



ordinary way of damping by means of a fluid, on the other hand, often requires great care in the management.—*Elektrotechnische Zeitschrift.*

THE ELECTRIC LIGHT AND HIGH TENSION CURRENTS.*

BY E. HOSPITALIER.

The use of high tension currents with underground cables presents still, if we are to credit Mr. Woodbury, of Boston—the inspector of an American insurance company—a certain number of practical difficulties which are yet far from being overcome. Several trials have been made in America without sufficiently satisfactory results having been obtained to lead to the adoption of subterranean conductors.

In a trial made at Boston with a cable 400 metres long, of which the initial insulation was 90 megohms, this insulation gradually fell, and caused important repairs to be so quickly required that it was soon abandoned.

A second line, lead covered, was similarly rendered useless at the end of a few months. The fault of this cable consisted in a disintegration of the insulating substance, quite different in many respects from that produced in overhead wires similarly insulated.

At Philadelphia several explosions of illuminating gas have been attributed to the discharges from an electric lighting circuit.

In Delaware-avenue an underground circuit, which was carefully overhauled and repaired, became in a short time so badly insulated that it was impossible to maintain the light, and an overhead wire had to be fixed in its place. The temperature was so great at the fault that the sand was found to be melted in places, and if these high temperatures were produced inside of dwelling houses in the neighbourhood of combustible materials, very grave consequences would result. A few weeks' experience of an underground circuit is not sufficient for one to find out if this circuit is capable of fulfilling all the conditions of arc lighting from a central station, as faults in conductors only reveal themselves with time.

The difficulties are much less with a low-tension system, such as Edison, where the tension hardly exceeds 100 volts, than in a system of arcs in series, as that of Brush or Thomson-Houston, where the tension may exceed 1,000 volts. In addition to their insulation, which is necessary whether the overhead or underground arrangement is used, subterranean cables should be protected from excessive dryness or excessive moisture, also from natural and accidental variations of temperature, from the action of drains or the escape of gas: they should be capable of resisting the mechanical strains produced in constructing and repairing the roads, and, moreover, they should be cheap.

All these conditions complicate the problem considerably, and, according to Mr. Woodbury, the question is so little advanced, at least in America, that at present underground conductors are considered an element of danger, in proportion to their defective insulation, and the necessity of constructing subterranean channels is against the interests of electricity.

It would be interesting to know the opinion of practical Europeans, and in particular of those who use high tension currents, as Messrs. Gaulard and Gibbs, or Messrs. Zipernowski and Deri. The opinion of Mr. Woodbury appears to us to be rather pessimist, and we shall await further information before pronouncing upon a question so intimately connected with the future of electricity.

* From *L'Electricien*, 19th June, 1886

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ELECTRIC LIGHT FOR CHELSEA.

Among the Metropolitan parishes which have seriously considered the subject of electric lighting, Chelsea has taken a leading part from the very first. The City area was the first to be lighted by electricity, but that circumstance was due to the enterprise of competing companies rather than to any initiative on the part of the City authorities. Chelsea, on the other hand, has investigated the subject in a very thorough-going fashion, has published reports by its surveyor, and has assed an independent judgment favourable, on the whole, to the new illuminant. But whereas the City has allowed the experimenting to be done by outsiders, and is now about to profit by it on its own account, Chelsea appears to have taken a vast deal of trouble only to prepare the way for somebody else. Nobody — except, perhaps, the parishioners — can complain of this, certainly not the CHELSEA ELECTRICITY SUPPLY COMPANY (Limited), who, having obtained a Provisional Order for lighting a portion of Chelsea, are so encouraged by the favourable reception of their scheme as to have pressed it on for confirmation in the House of Commons. The Bill is before us, and it may be useful to glance at it with a view to seeing how the Board of Trade are prepared to treat future negotiators applying for similar powers.

It strikes us as singular that, under existing circumstances, any electric lighting company has had the temerity to seek such powers under the Act of 1882, when that Act was on the point of being thoroughly recast in a shape, to say the least of it, twice as favourable to the undertakers as was the original Act under which the Chelsea Company obtained its Order. The Bill for amending Mr. CHAMBERLAIN'S Act has fallen through in consequence of the premature dissolution of Parliament; but it would appear that the Provisional Order for Chelsea was proceeded with on the basis of the unreformed Act. "This order," says the Bill, "is to be read and construed subject in all respects to the provisions of the Electric Lighting Act, 1882, or of any other Acts or parts of Acts incorporated therewith," by which we do not understand that subsequent legislation altering the conditions upon which provisional orders are to be granted will disturb the conditions under which provisional orders have already been confirmed. We take it that twenty years' grace, with compulsory purchase to follow, are the terms on which the CHELSEA ELECTRICITY SUPPLY COMPANY means to start business, if it does start, and that any better terms hereafter embodied in the original Act will be prospective merely, and not benevolently applicable to people who accepted the earlier and less liberal conditions. We may be mistaken in this view; but that would be a small matter. It would be a very serious matter, however, if the company were to make any mistake about it. We can only suppose that they have preferred to take all the risks and assume all the burdens rather than wait any longer.

Harsh as are the terms of the original Act, the Board of Trade have, it seems to us, made them worse under the confirming order, which bristles with obligations and restrictions, chiefly operative against the undertakers. For example, authority is granted over a certain area, with a nominal power to extend it to a wider prescribed area; but whereas the local authorities can virtually compel the undertakers to extend their operations, the undertakers can be prevented doing so on their own motion if the local authorities or the Board of Trade raise any objection. Again, the capital of the company is a prescribed sum—a very large one, we think, for a beginning—and it is to be virtually held by the Board of Trade and doled out as the work of the undertakers proceeds. And before beginning extensions in the wider area the Board of Trade has power to demand the deposit of such sums as they may think fit—and three-parts of the whole sum required within twelve months. It will be a fortunate concurrence of circumstances that enables any company to earn interest on its capital within a reasonable time under such conditions as these. The undertakers will also be working under the continued supervising and restrictive powers conferred on the METROPOLITAN BOARD OF WORKS and the POST-MASTER-GENERAL, whose rights in every respect are held sacred in this Bill. As regards the conditions under which the company is required to supply electricity, they may be inferred from the following example: "The undertakers upon receiving reasonable notice from the local authority requiring them to supply electricity to any public lamps within the distance of fifty yards from any distributing main . . . . shall give and continue to give a supply of electricity to such lamps in such quantities as the local authorities may from time to time require to be supplied." Thus the undertakers can be compelled to light "lamps"—two would answer the description—but cannot demand to be allowed to light three!

This last is, of course, the great obstacle to electricity competing with gas as a street illuminant. We have no desire to see any injustice done to gas by its premature displacement in favour of the electric light; but, on the other hand, it is rather hard on the vendors of electricity to arbitrarily compel its supply where no profit can be earned. In

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the particular area, however, to which this Bill relates there are good reasons for expecting a profitable return from private house lighting. Schedule A, the area first to be worked, comprises Sloane-street, with the region behind it, which is undergoing a complete and rapid transformation at the hands of the "Queen Anne" builders, and promoters of aristocratic "Flats." In a very short time every small dwelling house will have disappeared, and its site be occupied by a mansion which makes up in height what it lacks in breadth. The tastes likely to prevail in this sumptuous new colony will favour electric light, which has here a chance of starting without any rival more formidable than inodorous oil, which is exceedingly troublesome, whether it smells or not. No better locality could have been selected for making a start at indoor lighting on a tolerably large scale, and it is this fact probably that induced the CHELSEA ELECTRICITY SUPPLY COMPANY to begin operations, notwithstanding the 27th clause of the original Act and the onerous conditions imposed by the confirming order of the Board of Trade.

CORRESPONDENCE.

A NEW TYPE OF DYNAMO.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your last issue, when describing the new Goolden and Trotter dynamo you say:—"A very similar pattern has recently been produced by Mr. Kapp." Your expression "recently" is, however, somewhat misleading, because with the rapid progress going on all around us one is hardly justified in describing a thing as recent which is more than a few weeks old. Now, by referring to my books I find that the date of design and working drawings for the first single horse-shoe machine falls into the period from the 24th to the 27th July of last year, and that this machine was finished and tested on the 28th of August last year. Moreover, the type of field which you call a recent production, was described and illustrated last November in a paper I read at the Institution of Civil Engineers, and at that time several large dynamos of this pattern had already been made by Messrs. W. H. Allen and Co. to the order of the Admiralty.—Yours, &c.,

Wimbledon, June 21, 1886. GISBERT KAPP.

NERVOUS FORCE AND ELECTRICITY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have for the last two or three weeks been engaged on a series of experiments, the results of which are to me striking.

I noticed, in the first instance, that by simply holding in my dry hands the ends of two copper wires covered with gutta percha, and connected with the terminals of a Thomson mirror galvanometer, the needle of the galvanometer was deflected.

Let A and B represent the two terminals. When I speak of the needle deflected to the *right*, it signifies that the current enters the galvanometer through A, and to the *left* through B.

In order to get good contact I used salt water. Now, when I held A (*i.e.*, the wire attached to A) in my left hand, and B in my right hand, the spot of light went rapidly off the scale to the *left*; on the contrary, when A was in my right hand it went off to the *right*. I repeated this on another man, and confirmed the result. But, happening to come across a left-handed human being, I found to my delight that the reverse took place. Thus, when I placed A on his left thumb, the needle turned to the *right*; when on his right thumb, the deflection was to the *left*. I also proved that when one of the wires was in my mouth and the other in either of my hands the current always left my body at the hand; but when I pressed one of the wires against the centre of my forehead and held the other in a hand the current left at my forehead.

The left hemisphere of the brain controls the right side of the body, and the right hemisphere manages the left side.

So, as might be expected, when I held A against the left "bump" of my forehead and B on the right, the needle was deflected to the *right*, and to the *left* when A was on the right "bump."

In addition to these experiments there are several anatomical facts to support the view of the identity of nerve force and electricity. For instance, all the nerve fibres, at least in the cerebro-spinal system, are insulated from one another by what is known as "the white substance of Schwann.' And just as nerve force causes a muscle to contract, so does electricity when the centre of that nerve force has been taken away or destroyed. Witness Galvani's experiments, also an experiment by Dr. Ure, and quoted by Dionysius Lardner, in which the body of a recently executed convict was included in the circuit of a powerful battery:—"When the circuit was closed, the muscles moved with a fearful activity, so that rage, anguish, and despair, with horrid smiles, were successively expressed by the countenance." Finally, there are one or two analogies existing between the brain and a galvanic battery. The following have occurred to me:—

1. In the case of an electric battery, when the circuit is open the current will not flow; but still there is the difference of potential. Similarly, when a person is said to be "paralytic from disease affecting the motor tract," he yet retains the will to act, although not the ability. Thus the *will* corresponds to electromotive force.

2. An electric battery requires to be refilled after a certain amount of use. Exactly so with the brain. And during sleep, which is necessary for the restoring of the brain, the minute cells of the cortex generate a mysterious force with the aid of the blood, which I hope these experiments may tend in some measure to throw light upon.

There are many deductions to be made from these experiments, which, however, I must leave for the present. I am convinced that anything, however small, relating to that by which we live and move and have our being must be of consuming, as it is of vital, interest to all.—Yours, &c.,

ARTHUR WILLEY.

45, Gladstone-avenue, Noel Park, N.,
June 21st, 1886.

P.S.—There is just one deduction which I pick out from the rest, and should like to mention. The experiments seem to show that with right-handed people more nervous force is sent into the right than into the left arm, and the contrary with left-handed people. Thus it seems to me probable that the awkwardness which the former exhibit with respect to the left side and the latter with respect to the right side may in part be explained. Also those muscles which are called upon to do the most work get more nervous force than others which do less work. For example, the hands get more than the mouth.

MILITARY TELEGRAPHY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With reference to Baron von Fischer-Treuenfeld's letter in your last issue, may I be permitted to state that I was aware before writing my paper that enough had transpired in various ways about my vibration system to render a full description of it free from any risk of injury to the public service, while in other respects not altogether void of interest, otherwise the paper would not have been written?

As regards the German preference for the Inker, I concur with the writer of your very able leader in thinking it better to leave them to manage their own business, which they have certainly shown that they thoroughly understand. It may not, however, be amiss to point out that 10 miles of telegraph wire may be doing more important work than 1,000.—Yours, &c.,

P. CARDEW.

Chatham, 22nd June, 1886.

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LITERATURE.

Electric Transmission of Energy. By GISBERT KAPP, C.E. [London : Whittaker and Co., 1886.]

At a time when there is some hope that the consideration which this subject deserves is about to be accorded to it, the appearance of Mr. Gisbert Kapp's "Electric Transmission of Energy" is singularly opportune. Several years ago a work on the "Electric Transmission of Power" was written by Dr. Paget Higgs, but then the subject was only in its babyhood, and the data at the author's disposal was limited in quantity and of rather inferior quality. Since that work appeared, however, much has been done. The theory of dynamo machines and electro motors, as compared with the state in which it was then, may be said to be complete. The greater part of the mathematical work appertaining to the problem of electro-dynamic transmission is accomplished, and while a great deal has been written on the subject there exist not a few practical examples of its application. Although progress has not been so rapid as was expected in some quarters, and enthusiasts have suffered disappointment in this case as in most other cases, still the transmission of energy by means of electricity may be described as having attained a somewhat promising infancy if it cannot yet be said to have reached a vigorous manhood.

After reviewing in a few introductory pages what has been already accomplished, Mr. Kapp leads off with a chapter on general principles, in which is discussed the co-relation of physical forces, with special reference to the relation between mechanical and electrical energy. A portion of this chapter is devoted to an exposition of Prof. Hughes' theory of magnetism, and the derivation of electro-magnetic units. The happy conception of an ideal transmission system, consisting of two pairs of bars with a slider to each, forming one pair the generator and one the receiver, and connected by a pair of conductors, is introduced in this part of the work, and will be exceedingly helpful to the reader. In this ideal system there is no mechanical friction to deal with, and we have an analytical investigation of the condition for maximum work, whence is derived the well-known result that the counter E.M.F. of the motor must be equal to half that of the supply, or maximum work will be obtained when the motor is loaded, so that the current which flows is equal to half that which flows when it is at rest.

At page 40 the author refers to the starting-power, and points out that in separately excited motors the torque produced is proportional to the current flowing through the armature. Here it is assumed that no distortion, displacement, or weakening of the field is produced by the armature current, but with motors as usually constructed this would not be the case. The torque being proportional to the product of the strength of field and armature current, it is found that, owing to the weakening of the field, it does not increase in separately-excited motors quite so rapidly as the current, while in series motors, on the other hand, it increases more rapidly, the strength of the field up to a certain point being increased as the current is increased. This fact, as is pointed out, is of great importance in the application of motors to tramway or railway carriages.

Mr. Kapp very properly takes objection to the method of determining the efficiency of a system of transmission by comparing the relative speeds of the receiver and generator, since any leak on the line wire would cause the receiver to run at a higher velocity and thus show a higher efficiency under circumstances in which in reality a lower efficiency only is possible. But it is not so easy to see the force of the author's second objection, which he raises because "the two magnetic fields, although produced by the same magnetising power, are not of absolutely equal intensity, because the magnetisation of the armature produced by the current circulating through its coils has a certain influence in altering the intensity of the magnetic field, and this alteration is different in a motor to what it is in a dynamo." If in two identical machines the brushes in the motor have a displacement in a backward direction equal to that which in the dynamo is given to them in a forward direction, we ask why should the influence of the armature on the magnets be different in each case? The currents flowing in the armature and magnets of each are similar; the armature and magnet poles have therefore the same effect, and are in the same position relatively to each other. The resultant magnetic field has the same shape, and, in the absence of anything corresponding to magnetic lag, a notion which appears to be exploded, we do not see how the mere rotation of the armature in a different direction—for this is the only point of difference between the machines—can influence the E.M.F. produced. We do not know the precise conditions under which the curves from the Bürgin machines exhibited at page 126 were obtained, but unless the magnetically irregular form of the armature in some way influenced the field due to its rotation, we should have expected the counter E.M.F. line to coincide with the dynamic E.M.F. line if the brushes were displaced in the former as far backward as in the latter forward, and we should be surprised if in smooth armatures this were not the case. In short, with similar resultant field and similar currents we ought to have produced the same E.M.F.

In Chapter II. the author proceeds from the abstract to the concrete, and describes the results obtained with actual armatures running in actual fields, the expression for the electromotive force produced by an armature of given dimensions being given at page 81. A considerable portion of the chapter deals with the effect of self-induction on motors with shuttle-wound armatures where the counter E.M.F. necessarily alternates twice in each revolution from zero to maximum. Several experiments, details of which are given, lead to the conclusion that in the case of series motors with shuttle-wound armatures of the Griscom type the effect of self-induction by retardation of the magnetism is to steady the current, and thus prevent waste of energy at the dead points where the counter E.M.F. is *nil*. With shunt motors, on the other hand, the self-induction has no effect, and there is a consequent rush of current when the armature is at the dead points, the flow of current which was simply undulatory in the former case being in the latter case subjected to violent changes.

Further on it is observed that the current is independent of the speed, but depends simply on the loads, and that the ratio of E.M.F. to speed is constant; in other words, with a given current the E.M.F. is proportional to the speed as is the case in generators. In discussing the loss of energy due to discontinuity of the armature core, the formation of eddy currents in the poles caused by the sweeping of the Pacinotti teeth over their surfaces is referred to, and the fact that these can be prevented by sufficient clearance between the teeth and the surface is also stated; but Mr. Kapp doubts whether there is any advantage in employing the Pacinotti instead of the usual Gramme type of armature. If there is one requirement more than another on which throughout the book emphasis is laid, it is that the wires carrying the current shall be driven positively by some rigid fastening to the armature, and in his own dynamo Mr. Kapp ensures this by providing radial driving-horns protruding from the gun-metal flanges, between which the iron wire of his core is wound. By some this positive method of driving is not considered essential, but there can be no doubt that if the Pacinotti armature, because of the positive way in which the wire is driven, should ever be employed at all, it is in motors where the torque in starting them is often five or six times that at which they are usually worked.

In Chapter IV. are discussed the different types of field magnets employed in modern dynamos, and formulæ from which we can obtain the strength of field in terms of the ampere-turns are given. These formulæ are only true for very low degrees of magnetisation, since the magnetic resistance of the iron in the armature and magnets increases with the degree to which it is saturated. From numerous experiments Mr. Kapp finds that the magnetic resistance of air is about 700 times that of soft wrought iron well annealed. This is when the field is very weak, but in practice, when the magnets are fairly saturated, the resistance of the iron frequently rises to ten times its original value, in which case the magnetic resistance of air is only 70 times that of iron. Further on, at page 111, Mr. Kapp, in consequence of difficulties experienced

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when the saturation effect comes into play, abandons the formulæ referred to in favour of representation by graphic methods.

In chapters V. and VI. the author gives his attention to various systems of transmission, and includes in his considerations systems in which the motors are fed by mains at a constant difference of potential, or by a constant current, and systems in which only a single motor is fed at a distance from a single generator. In these cases it is supposed that the motor has to run at a constant speed, and it is also supposed that the speed of the generator shall remain uniform. If in a motor in which the resistance of the armature is very low the magnets are excited by a current which is constant, it may be very nearly self-regulating, the E.M.F. expended in overcoming the resistance of the armature being negligible. In a shunt-motor we can, therefore, by making this resistance sufficiently low, get a machine in which, when fed by a constant E.M.F., the speed does not vary enough to form in practice any objection to its use. Such a motor would do very well to be used in a system where the mains were kept at a constant difference of potential, but another method, namely, that of compound winding, devised some time ago by Profs. Ayrton and Perry, to achieve constant speed with constant potential, may be briefly noticed. When the load on a shunt motor is increased, an additional E.M.F. is expended in the armature, and less is therefore available for external work. The speed with a constant field depends on the difference between the E.M.F. at the motor terminals and that expended in the armature, and it is at once diminished with an increased load. If the speed is to have its original value with a diminished counter E.M.F. it is evident that the field must be weakened, and this Ayrton and Perry accomplish by winding a demagnetising coil on the magnets in series with the armature, so that the increased current weakens the magnets. It must not be supposed for a moment that a compound dynamo will work satisfactorily as a compound motor. It is true the same *kind* of winding is required, inasmuch as they both have a shunt and series coil, but the *proportions* must be very different, and the shunt coil in a compound motor must saturate the magnets to the degree to which they are in a compound dynamo saturated by the shunt and series coils combined. Compound motors we have seen at work; but we have not been particularly struck by their performance. They are an awkward piece of designing. Different to compound dynamos they have, when the current through the armature is a maximum, the weakest field, and are, therefore, extremely liable to sparking unless the turns on the armature are very few. But few turns on the armature means low resistance, and this, as we have said before, may mean a diminution of speed which is inconsiderable. *En passant*, by reason of the current in the armature reacting to weaken the field, does not a shunt motor contain within itself the germ of self-regulation, which by suitable proportion may be made effective without a series coil at all?

To work on a constant current system Mr. Kapp proposes the combination of a motor with a dynamo running at its critical speed. The armature of the latter is fixed on the motor spindle, and tends to demagnetise the field coils of the former. We do not believe that any method of governing which depends upon the action of a dynamo running at its critical speed can be successful; but we wait expectantly for the results obtained from the combination, trusting that the collector will not be ruined by sparking before a sufficient number of readings can be taken.

Passing from our consideration of motors working independently of each other on a constant potential or constant current system, we come to the case of a single motor worked by a single generator. The shunt motor may be employed as a receiver, in which case we have to supply at the motor terminals a constant potential, or potential which may rise somewhat according to circumstances. In consequence of the line having a certain resistance, the E.M.F. at the generator must rise probably 20 per cent., in order that the necessary potential be supplied to the motor, and it is pointed out that an over-compounded dynamo satisfies the requirements for the generator. Of course approximation only is meant here, as it would not be possible to obtain a rise of, say, 20 per cent. in E.M.F. in anything like a straight line without an excessive quantity of iron. Adjustment is possible whereby similar speeds can be obtained from the motor working idly and with full load, but between those two limits there must necessarily be a certain increase. Mr. Kapp instances a curious practical objection to this system of over-compounded dynamo and shunt motor which we have not time to consider, but of which a description was published in *The Electrician* of April 18th, 1885. The difficulties which were encountered in working the system may be avoided by keeping the magnet circuit of the motor always closed, the switch to stop and start the motor being placed in the armature circuit only.

The other transmission system to which reference is made consists of a series-wound motor worked by a series-wound generator, a system which is undoubtedly most advantageous, being self-regulating, if the difference between the ordinate heights of the characteristics of the generator and motor is for all currents equal to the E.M.F. spent in overcoming the resistance of the circuit.

We do not quite see how Mr. Kapp finds γ, the current required to overcome internal friction (page 130). The value of γ, when the motor is running empty, is different to its value when the motor is fully loaded, and if four amperes overcomes the internal friction when running idle, we should imagine something considerably over this would be required when there is a total current of 45 amperes flowing. But although the quantity γ may be somewhat higher than the determination given, still the main fact which the author desires to point out should be carefully noted, and that is, that whereas in a motor having no mechanical friction the efficiency is a maximum when the counter E.M.F. approaches that of the generator, this is not the case when the work expended in internal friction is taken into account.

In Chapter VII. Mr. Kapp considers the question of conductors, and interprets in its proper sense the law of Thomson. It must be remembered that the cost of conductors cannot be expressed simply as proportional to the weight of copper plus a constant for laying, and it is likely that some graphic method of connecting the cost with the line resistance will have to be adopted for each district in order that a correct solution for minimum cost may be arrived at. Again, as has been lately shown by Ayrton and Perry, the truth of the law for minimum cost depends entirely on the way in which the problem is conditioned. If the current is fixed and the resistance only is variable, Thomson's law is applicable; but if the potential at the generator is fixed and the power to be delivered at a distance from it is also fixed, both the current and resistance are variables, and maximum economy is obtained not by keeping the current density constant, but by making it diminish as the length of the line becomes greater. In all cases where the maximum potential at the generator is given, a current smaller than that given by Thomson's formula must be used to obtain maximum economy.

Chapter VIII. deals with the various materials employed for conductors, &c., and in Chapter IX. are given some interesting results relative to the efficiency of power transmission by wire rope, hydraulic, pneumatic, and electric methods. These results are based on the investigations of Herr Beringer, and show that for distances of less than three miles transmission by wire rope is more economical than by any other system. For distances greater than this electric transmission is the most economical. As regards capital outlay, up to about two miles the wire rope is cheapest; beyond this, electric transmission is least costly. Summarising the results obtained by combining the capital outlay and efficiency, Mr. Kapp arrives at the following conclusions:—

1. It pays to transmit cheap water-power; by wire rope if the distance is less than a mile, and electrically if the distance is a mile or more. This applies to all powers.

2. It pays to transmit cheap steam-power if the amount of energy required at the receiving station does not exceed 10 horse-power. If the distance is less than a mile use wire-rope transmission; for distances of one mile and upwards, up to two or three miles, use electric transmission. Beyond this limit a small local steam or gas engine is preferable.

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According to this three miles is the limiting distance for economical electric transmission if steam power is transmitted. Obviously, our hopes of electric transmission must for the future be centred in water power.

Chapter X. deals with the different forms of modern dynamo, and Chapter XI. describes the various systems of transmission now at work. We recommend readers to study these chapters carefully; for the present we have only space to call attention to an estimate at the end of Chapter XI., where the original outlay for electric traction on tram lines is shown to be only slightly in excess of that required for horse traction, while the annual working expenses for horses is more than double that for electricity.

Chapter XII., describing the successes and failures of M. Marcel Deprez, concludes a valuable work, which we hope to see run through several editions. It is possible that a somewhat better arrangement of the subject matter might be adopted, but doubtless many difficulties of classification have been experienced. Mr. Kapp is not an enthusiast, and the book is written with regard to facts and to facts only. Every circumstance for and against the electric transmission of energy is carefully weighed, and the author, if he gives us no hint as to the future, prohibits by his treatment any charge being brought against him of over sanguineness. What the future may bring we do not know, it is sufficient that we grapple with problems as they are presented to us.

ON THE LIFTING POWER OF ELECTRO-MAGNETS AND THE MAGNETISATION OF IRON.*

BY SHELFORD BIDWELL, M.A., LL.B.

The author believes that no very recent investigations have been made with reference to the maximum lifting power which an electro-magnet is capable of exerting, the experiments conducted by Joule between the years 1839 and 1852 still forming the basis of most of our practical knowledge on the subject.

It is a matter of common experience that if an electro-magnet be excited by a gradually increasing current a limit is soon reached, beyond which the ratio of increase of sustaining power to increase of current becomes rapidly smaller; and it has generally been assumed that this ratio continues to diminish indefinitely, so that an infinite current would not impart to a magnet much greater lifting power than that which it possesses when an approach to saturation is first indicated.

Joule, after having shown by experiment that the power of an electro-magnet varies as its sectional area, expressed the opinion that "no force of current could give an attraction equal to 200lb. per square inch," and much later Rowland stated, as a probable result of his well-known researches in magnetic permeability, that the greatest weight which could be sustained by an electro-magnet with an infinite current was, for good but not pure iron, 177lb. per square inch, or 12,420 grams per square centimetre of section.

It has long been known that when an iron rod is magnetised its length is in general slightly increased. Some experiments on this effect of magnetisation, an account of which has been given in two papers recently communicated to the Royal Society, show that if the magnetisation is carried beyond the point at which the magnetic elongation of the rod reaches a maximum, the length of the rod, instead of remaining unchanged, steadily diminishes, the curve expressing the relation between the length and the magnetising force descending in a perfectly straight line, which within the limit of the experiments shows no tendency to become horizontal. Some further experiments (not yet published) have also been made with rings of iron instead of rods, and effects of precisely the same character were obtained. The diameter of a ring was found to be increased by a comparatively small magnetising current, and diminished by a strong one. Now, the retraction in question does not begin to occur until after the stage of magnetisation, loosely called the "saturation point," has been passed, when, according to the common belief, the magnetisation of the iron has practically reached a limit, and is not sensibly affected by any further increase of the magnetic force; and hence arises a difficulty in accounting for the phenomenon. The most obvious method of explaining the retraction is to assume that, under the influence of increasing currents, the magnetic attraction of the particles of the iron towards one another is increased, and thus the rod becomes compressed. But this cannot be the case if the magnetic condition of the iron has become constant and independent of the magnetising current. And a similar objection will apply to any hypothesis which assumes (as perhaps all must) that some property of the iron dependent upon its magnetic condition varies in a sensible degree with the magnetising force after the "saturation point" has been passed.

The author was led by considerations of this nature to the belief that it would be desirable to make some experiments with the view of ascertaining whether the lifting power and general magnetic condition of an iron rod are as nearly uniform under strong magnetising forces as is commonly supposed. Two pieces of apparatus were therefore prepared. The first consisted of a rod of iron hooked at each end and divided transversely in the middle, together with a long solenoid, inside which the divided rod could be placed. The second was an iron ring cut into two equal parts, each of which was encircled with a coil of insulated copper wire. In both cases the construction was such that an intense magnetic force could be produced with comparatively small battery power. The divided ring could be used either as a semi-circular electro-magnet with a semi-circular armature, or, if the current were passed through both coils, as two semi-circular electro-magnets.

Merely to test the hypothesis of Joule and Rowland, two or three determinations were made of the weight which could be sustained when the current was caused to circulate around one only of the semi-circles, the other being used as an armature. With a current of 4·3 amperes the weight supported was 13,100 grams per square centimetre of surface; with a current of 6·2 amperes the weight supported was 14,200 grams per square centimetre. In the latter case, therefore, the lifting power exceeded that which both Joule and Rowland considered the greatest that could be imparted to a magnet by an infinite current. Had it been worth while to incur the risk of injury to the insulation of the coil, there is no doubt whatever that by applying stronger currents the lifting power might have been carried still further, for there was no indication that a limit was being approached. But it was of greater interest to study the effects produced when both portions of the ring or of the rod were under the direct influence of the magnetising coil.

The first experiment was made with the divided rod. One portion was supported by means of its hook in a vertical position; a scale pan was attached to the hooked end of the other portion, and the flat ends of the two were brought into contact and surrounded by the solenoid. Currents of gradually increasing strength were then caused to pass through the solenoid, and note was taken of the greatest weight which could in each case be placed in the scale-pan without tearing asunder the ends of the two rods. The general results are briefly as follow:—When the intensity of the field at the junction had reached about 50 C.G.S. units, the weight supported was nearly 7,000 grams per square centimetre of the section of the rod. After this value was exceeded it became quite evident that the weight which could be sustained was increasing more slowly than the magnetising current, and the proportionate increase became rapidly smaller as the current was made stronger. This state of things continued until the intensity of the field was about 270 units, when the weight supported amounted to 10,800 grams per square centimetre of section. But from this point onwards *the magnetising current and the weight that could be carried increased in exactly the same proportion.* The rate of increase of the load was, indeed, comparatively small, but it was perfectly constant, and continued so until the field had attained the high intensity of

* Abstract of paper read before the Royal Society, May 20, 1886.

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1,074 C.G.S. units. Here the experiment was stopped, the greatest weight supported having been 15,100 grams per square centimetre.

On account of some uncertainty as to the possible influence of the external ends of the divided rod, it was thought desirable to make the experiment with the divided ring, the current being caused to pass in the same direction through the coils surrounding both portions. The general character of the results was the same as before, but the weight supported per unit of area was from first to last somewhat greater. The falling off in the rate of increase of the lifting power was well marked when the intensity of the magnetic force had reached 50 C.G.S. units, at which point the weight sustained was about 10,000 grams per square centimetre, and it continued to diminish until the magnetic force was 250 units and the weight supported 14,000 grams. From this point the increments of lifting power and of magnetic force appeared to be exactly proportional, and continued to be so until the magnetic force had been carried up to 585 units, when the limit of the battery power was reached and the experiment stopped, the maximum weight supported having been 15,905 grams per square centimetre or 229·3lb. per square inch.

Detailed results of the experiment with the divided ring are given in the first and second columns of the table. A curve plotted with the magnetic forces as abscissæ and the weights lifted as ordinates becomes sensibly a straight line, inclined to the horizontal axis for values of the magnetic force greater than 240 units.

It occurred to the author that these results might be applied to the investigation of the changes of magnetisation which correspond to changes of magnetic force. The common belief that at a comparatively early stage the intensity of magnetisation becomes sensibly constant is, he thinks, founded rather upon inference than upon actual observation. At all events, he is acquainted with no experiments bearing upon the subject which have been made with magnetic forces at all comparable in magnitude with those used by himself.

If W = the grams weight supported per square cm. of section, $\mathfrak{H}$ = the magnetic force, and $\mathfrak{T}$ = the magnetisation, we have

$$Wg = 2\pi\mathfrak{T}^2 + \mathfrak{H}\mathfrak{T},$$

and by giving to W the values found by experiment to correspond with different values of $\mathfrak{H}$, we have the means of finding corresponding values of $\mathfrak{H}$ and $\mathfrak{T}$. These are given in the first and third columns of the table. Here, again, it will be seen that when $\mathfrak{H}$ has exceeded the value of about 200, the ratio of $\mathfrak{T}$ to $\mathfrak{H}$ no longer continues to diminish, and the curve expressing the relation between them apparently becomes a straight line.

It is not suggested that the portions of both the curves for W and $\mathfrak{H}$ and for $\mathfrak{T}$ and $\mathfrak{H}$, which so far as the experiment goes, differ insensibly from straight lines, would in fact continue to appear as absolutely straight if they were prolonged indefinitely. It is, indeed, probable, that at least one of them tends to a limit; but the experimental results give no indication of the existence of any such limit, and if there is one it must be considerably higher than it is generally believed to be.

If κ denote the susceptibility, μ the permeability, and $\mathfrak{B}$ the magnetic induction,

$$\mathfrak{T} = k\mathfrak{H},$$

$$\mu = 1 + 4\pi\kappa,$$

and

$$\mathfrak{B} = \mu\mathfrak{H}.$$

We can, therefore, easily find the values of K, μ, and $\mathfrak{B}$, which correspond to different values of $\mathfrak{H}$. These are given in the fourth, fifth, and sixth columns of the table.

In connection with the well-known experiments and views of Prof. Rowland the figures thus obtained are of the highest interest. In order to exhibit the results of his experiments in the form of a curve which (as he believed) would be of finite dimensions, Rowland adopted the method of plotting the values of μ as ordinates against those of $\mathfrak{B}$ as abscissæ. The curve of μ thus obtained, after reaching a maximum for a moderate value of $\mathfrak{B}$ (about 5,000), fell very rapidly, and ultimately to all appearance in a perfectly straight line, towards the horizontal axis, which, however, was not quite reached. Rowland, therefore, assumed that the line would continue to be straight until it met the axis at a point the abscissa of which would indicate the greatest possible value of $\mathfrak{B}$ for an infinite magnetic force. He thus arrived at the conclusion that for ordinary bar iron the maximum of magnetic induction was about 17,500 units. For pure iron he thought it might reach 18,000, or even go above that.

Now, the magnetic force used in Rowland's experiments was very small, the highest value being only 64 C.G.S. units. The imaginary part of his curve therefore corresponds to values of $\mathfrak{H}$ ranging from 64 to infinity. A part of this exceedingly wide gap is filled by the author's experiments, which include values of $\mathfrak{H}$ up to 585, and a curve constructed from the values of μ and $\mathfrak{B}$ in the fifth and sixth columns of the table seems to throw much new light on the subject. It corresponds, of course, only with a portion of Rowland's curve, the lowest value of $\mathfrak{B}$ included in it being 7,390. Beginning with a rapid descent, it turns aside soon after the limit of Rowland's observations has been passed, and ultimately when $\mathfrak{B} = 19{,}800$ it has become almost parallel to the horizontal axis. We may conclude then that if $\mathfrak{B}$ has any ultimate limit at all, it is certainly very much higher than that which was assigned to it by Rowland.

There may, perhaps, be some doubt whether the expression used to connect W and $\mathfrak{T}$ is exactly applicable to the case of the divided ring, and small errors may possibly be introduced by the fact that the contact between the opposite faces was not quite perfect throughout. But apart from minute accuracy of detail, the general character of the results is entirely free from doubt, and would be quite unaffected by a very large margin of uncertainty in the expression. They show that the generally accepted ideas with regard to several important points need modification.

Thus it is not true that the lifting power of an electromagnet reaches a practical limit under a comparatively small magnetising force, and that even if excited by an infinite current it could not support a weight of 200lbs, per square inch of surface.

It is not true that the magnetisation of iron becomes sensibly constant when the magnetic force exceeds a certain moderate value.

And it is not true that the maximum of magnetic induction, if it exists at all, is represented by anything like so small a value as 18,000 units.

In conclusion, the author has to express his great obligation to Lord Rayleigh for much valuable assistance and advice in the preparation of this paper.

TABLE.

$\mathfrak{H}$	W	$\mathfrak{T}$	κ	μ	$\mathfrak{B}$
3·9	2210	587	151·0	1899·1	7390
5·7	3460	735	128 9	1621·3	9240
10·3	5400	918	89·1	1121·4	11550
17·7	7530	1083	61·2	770·2	13630
22·2	8440	1147	51·7	650·9	14450
30·2	9215	1197	39·7	500·0	15100
40	9680	1226	30·7	386·4	15460
78	11550	1337	17·1	216·5	16880
115	12170	1370	11·9	150·7	17330
145	12800	1403	9·7	122·6	17770
208	13810	1452	7·0	88·8	18470
293	14350	1474	5·0	64·2	18820
362	14740	1489	4·1	52·7	19080
427	15130	1504	3·5	45·3	19330
465	15275	1508	3·2	41·8	19470
503	15365	1510	3·0	38·7	19480
557	15600	1517	2 7	35·2	19630
585	15905	1530	2·6	33·9	19820

$\mathfrak{H}$ = magnetic force. W = weight in gms. per sq. cm.
$\mathfrak{T}$ = magnetisation. $\mathfrak{B}$ = magnetic induction.
κ = susceptibility. μ = permeability.

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ELECTRICAL THEORIES.

BY PROF. J. J. THOMSON, M.A., F.R.S.

(Continued from page 518, Vol. XVI.)

Substituting for u this last value, we see

$$\nabla^2 F = \frac{4\pi\mu}{\sigma}\left\{\frac{dF}{dt}+\frac{d\phi}{dx}\right\}+K\mu\left\{\frac{d^2F}{dt^2}+\frac{d^2\phi}{dx\,dt}\right\},$$

thus in the dielectric the equation becomes

$$\nabla^2 F = K\mu\left\{\frac{d^2F}{dt^2}+\frac{d^2\phi}{dx\,dt}\right\},$$

in the conductor

$$\nabla^2 F = \frac{4\pi\mu}{\sigma}\left\{\frac{dF}{dt}+\frac{d\phi}{dx}\right\}.$$

The equation for the dielectric shows that it represents a wave-motion propagated with the velocity $1/\sqrt{\mu}$; the numerical value of this velocity agrees very approximately with the velocity of light, and this led Maxwell to the theory that the changes in the structure of the dielectric which take place when the dielectric is polarised are of the same nature as those which constitute light. This theory, which is called the electro-magnetic theory of light, might almost as justly be called the mechanical theory of dielectric polarisation. Kirchhoff, in his paper, "Ueber die Bewegung der Elektricität in Drähten" (Pogg. *Ann.*, Vol. C. 1857; *Gesammelte Werke*, p. 131), was the first to point out that some electrical actions are propagated with the velocity of light. In this paper he considers the motion of electricity in wires whose diameters are small compared with their length. There are three things which have to be considered in this problem—(1) The self-induction of the electric current, and if the medium be taken into account, that of the polarisation currents in the dielectric. This self-induction produces very much the same effect as if the electric current possessed momentum. (2) The electrostatic action of the free electricity which tends to bring things to a definite state, and corresponds very much to the spring in a material system. Then, lastly, there is the electrical resistance, which corresponds to friction in an ordinary system. We see from the analogy that if the resistance be small enough, the electrical system will vibrate; if, however, the resistance is large, the electrical disturbance will be propagated in the same way as heat. Kirchhoff in his paper considers the propagation of electrical disturbance along a wire under various conditions; we shall only consider here one of these cases, that of an endless wire. In his solution Kirchhoff only considers the self-induction of the current flowing along the wire; he does not consider the effects in the surrounding dielectric. He shows that if e be the quantity of electricity per unit length of the wire, and

$$e = X \sin ns,$$

where s is the length of a portion of the wire measured from some fixed point, then X satisfies the differential equation

$$\frac{d^2X}{dt^2}+\frac{c^2 r}{16\gamma l}\frac{dX}{dt}=\frac{c^2}{2}\frac{d^2X}{ds^2},$$

where c is a quantity which occurs in Weber's theory, and is the velocity with which two charged particles must move if the electrodynamic attraction between them balances the electrostatic repulsion;

r is the resistance of the wire in electrostatic measure; $\gamma = log\ l/a$, where l is the length of the wire and a the radius of its cross section. The form of the solution of this equation depends on the magnitude of

$$\frac{32\gamma}{cr\sqrt{2}}nl.$$

If this quantity be large, the solution takes the form representing the propagation of a wave along the wire with the velocity $c/\sqrt{2}$. Weber's researches show that this velocity is very nearly equal to the velocity of light. If, however, the above-mentioned quantity be small, then the solution of the equation takes the same form as the formula which expresses the conduction of heat along the wire. We must not, however, take this to mean that the electric disturbance is propagated with an infinite velocity, so that if we had an infinitely delicate electrometer at a definite distance from the source of disturbance we could detect an electrification after an indefinitely short time, for it seems obvious that the electrical resistance cannot increase the velocity of propagation any more than the resistance of the air could increase the velocity of propagation of a disturbance along a line of particles connected by an elastic string. The conditions at the end help to determine the form of the solution, and these cannot make themselves felt until the disturbance has reached it; thus the heat form of solution probably only holds after a time from the commencement of the disturbance greater than the time taken by light to travel along the wire. If we take the case of a copper wire one square centimetre in area, we shall find that the wave form of solution will hold if the wire is not more than 100 miles in length, while the heat form will correspond to wires which are much longer than this. Kirchhoff's solution only refers to the propagation of a disturbance in a conductor, while Maxwell's refers to the propagation of such a disturbance in the dielectric.

Maxwell considers the effect of the motion of the medium on the electromotive force; he shows that the electromotive force parallel to the axis of x

$$= cv - bw - \frac{dF}{dt} - \frac{d\psi}{dx},$$

where u, v, w are the components of the velocity of the medium conveying electric action. Here ψ is not the electrostatic potential merely; it is equal, as Helmholtz has shown,* to the electrostatic potential plus the term

$$Fu + Gv + Hw.$$

We must remark here that u, v, w are the components of the velocity of the medium conveying the electric action, *i.e.*, the ether, and this need not necessarily be the same as the velocity of the dielectric.

Von Helmholtz's Dielectric Theory.

Von Helmholtz, in the paper† to which we have so often referred, considers the effect of the polarisation of the dielectric; he supposes that when an electromotive force X, parallel to the axis of x, acts on an element of a dielectric, it puts it into such a state that it produces the same effect as if there were electricity of surface-density x on the face $dy\,dz$ of the element, and an equal quantity of electricity of the opposite sign on the parallel face, x being given by the equation $x = \epsilon X$, the variations in the electromotive forces acting on the dielectric are supposed to produce the same effect as ordinary conduction currents whose components are $\dot{x}$, $\dot{y}$, $\dot{z}$, where x, y, z are the components of a vector quantity which in isotropic media is parallel to the electromotive force and equal to the product of ϵ and the intensity of the force. This agrees with Maxwell's assumption, provided $\epsilon = K/4\pi$, where K is the specific inductive capacity of the dielectric. If ϕ be the electrostatic potential of the free electricity, ψ the potential due to the polarisation of the dielectric, then Helmholtz shows that

$$\frac{d}{dx}\left\{(1+4\pi\epsilon)\frac{d}{dx}(\phi+\psi)\right\}+\frac{d}{dy}\left\{(1+4\pi\epsilon)\frac{d}{dy}(\phi+\psi)\right\}+\frac{d}{dz}\left\{(1+4\pi\epsilon)\frac{d}{dz}(\phi+\psi)\right\}=-4\pi E,$$

where E is the volume-density of the free electricity. The corresponding equation in Maxwell's theory is of the same form, provided $1+4\pi\epsilon = K$.

This relation seems inconsistent with the previous one; it may, however, be reconciled with it in the following way:—

The potential due to a quantity E of electricity at a point distant r from it is proportional to

$$\frac{E}{(1+4\pi\epsilon)r}.$$

* *Ueber die Theorie der Elektrodynamik; die Elektrodynamische Kräfte in bewegten Leitern*, "Crelle," LXXVIII., p. 309; "Gesammelte Werke," II., p. 745.

† *Ueber die Theorie der Elektrodynamik*: "Crelle," LXXII., p. 57; "Gesammelte Werke," I., p. 544.

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If ϵ_0 be the value of ϵ for air, the potential under the same circumstances in air is proportional to

$$\frac{E}{(1+4\pi\epsilon_0)r};$$

if, then, we define unit potential as the potential at unit distance from unit of electricity in air, the potential due to a quantity E in another medium will be

$$\left\{\frac{1+4\pi\epsilon_0}{1+4\pi\epsilon}\right\}\frac{E}{r}.$$

We see that this is equivalent to increasing the unit of potential, and therefore the unit electromotive force, $1+4\pi\epsilon_0$ times, so that if we use the new unit the equations will be

$$x=\frac{\epsilon}{1+4\pi\epsilon_0}X,$$

$$\frac{d}{dx}\left\{\frac{1+4\pi\epsilon}{1+4\pi\epsilon_0}\frac{d}{dx}(\phi+\psi)\right\}+\ .\ .\ .\ .\ .=-4\pi E.$$

These will coincide with Maxwell's equation if we make ϵ and ϵ_0 each infinite and put $K=\epsilon/\epsilon_0$.

Returning to Helmholtz's theory, if u, v, w are the components of the total current

$$u=p+\dot{x},\quad v=q+\dot{y},\quad w=r+\dot{z},$$

where p, q, r are the components of the conduction current.

Helmholtz puts

$$\frac{du}{dx}+\frac{dv}{dy}+\frac{dw}{dz}=-\frac{d\rho}{dt}$$

where ρ is the volume-density of the free electricity, and if σ be the surface-density of the free electricity at any point of a surface separating two media, u_1, v_1, w_1; u_2, v_2, w_2, the components of the current in the two media, l, m, n the direction cosines of the normal to the surface drawn from the first medium to the second, then according to v. Helmholtz

$$l(u_1-u_2)+m(v_1+v_2)+n(w_1-w_2)=\frac{d\sigma}{dt}.$$

According to Maxwell the corresponding equations are

$$\frac{du}{dx}+\frac{dv}{dy}+\frac{dw}{dz}=0,$$

$$l(u_1-u_2)+m(v_1-v_2)+n(w_1-w_2)=0.$$

As it is in the difference between these equations that the difference in the theory really lies, it will be instructive to look at them from another point of view. We know of no way in which the quantity of free electricity can be altered except by electricity being conveyed by conduction currents to the place where the alteration takes place. Assuming, then, that the alteration in the density is caused by such currents

$$\frac{dp}{dx}+\frac{dq}{dy}+\frac{dr}{dz}=-\frac{d\rho}{dt},$$

$$l(p_1-p_2)+m(q_1-q_2)+n(r_1-r_2)=\frac{d\sigma}{dt}.$$

So that Helmholtz's equations taken in conjunction with these are equivaient to the condition

$$\frac{d\dot{x}}{dx}+\frac{d\dot{y}}{dy}+\frac{d\dot{z}}{dz}=0;$$

$$l(\dot{x}_1-\dot{x}_2)+m(\dot{y}_1-\dot{y}_2)+n(\dot{z}_1-\dot{z}_2)=0.$$

Thus on Helmholtz's theory the dielectric currents behave like the flow of an incompressible fluid, while on Maxwell's theory it is the total current which is the sum of the conduction currents and the dielectric currents which behave in this way.

(To be continued.)

WEST COAST OF AMERICA TELEGRAPH COMPANY.—The coupons due on the 30th inst. on the debentures of this company will be paid by Messrs. Barclay, Bevan and Co., of Lombard-street, E.C. The coupons must be left three clear days for examination.

THE ROYAL HOLLOWAY COLLEGE.

The 30th of the present month will be a red letter day in the annals of Egham, for then Her Majesty the Queen will open what is destined to become one of the most influential institutions in the United Kingdom, the Royal Holloway College for the Education of Women, a monument of practical benevolence of which it is perhaps not too much to predict that it will long survive those specifics by which the name of its founder has become a household word, and by the sale of which he raised his immense fortune. Had the deceased philanthropist consulted his own inclinations only it is more than probable that his wealth would have been devoted, we will not say to a better or to a more useful purpose, but at least to some object in the benefit of which a portion of the mass of mankind who constituted the principal *clientèle* by whom that wealth was created would have participated. This, however, will by no means be the case. The college, which is really a scheme of the deceased's wife, is to be dedicated to the higher education of women of the upper middle classes—a subject in which she took a deep interest—and will be all but self-supporting. Indeed, so far as we have been able to ascertain, the conditions of admission to the enjoyment of its privileges are essentially prohibitive to all except the well to do, notwithstanding that beyond the £600,000 which has already been spent in the purchase of the freehold, and in the erecting and furnishing of the institution, £100,000 has been left by way of endowment to it. For this reason we do not doubt that there will not be wanting many who, forgetting the homely adage that one should never look a gift horse in the mouth, will question the wisdom, if not the motives, of the donor. So far, the trustees who were left to carry out the project are to be congratulated on its achievement, in which neither labour nor money has been spared. Indeed, the edifice itself, which is situated on Mount Lee, the *demesnes* of which embrace about 95 acres of land of pastoral beauty unsurpassed perhaps in England, has been constructed on a princely scale of magnificence, satisfying at once all the claims of art and hygienic science. It is of the architecture peculiar to the period of the French Renaissance, being in the form of a huge parallelogram, divided by a central block, which forms it into two quadrangles in the interior. The entire structure is of red brick and Portland stone, the latter exhibiting some excellent specimens of ornamental masonry. Some conception of the size of the college may be gathered from the fact that it is about seven years since Mr. Martin G. Holloway laid its foundation stone, and that there are upwards of 1,000 rooms in it, providing accommodation for 250 students, with their teachers. In addition to these, there are a dining room, a library, a museum, recreation hall, and a chapel, the latter forming one side of the northern façade, and being decorated in the interior with some rich examples of fresco painting of sacred subjects, and of bas relief resembling in style what is to be seen in the Royal Palace at Fontainbleau. A valuable collection of paintings, bought at sales at various times by Mr. Holloway for £90,000, including some of the choicest works of the best known English masters, adorns the walls of the recreation hall, turning it into a veritable picture gallery not unworthy of a room in the national collection in Trafalgar-square. Such is a very imperfect outline of the luxurious manner in which the trustees have carried out the bequest committed to them. Not the least among the many advantages which the future residents at Mount Lee will possess will be an installation of the electric light, of which it is our more immediate purpose to speak. This has been entrusted to the well-known engineers, Messrs. B. Verity and Sons, of King-street, Covent-garden. The electric lighting of the college may be said to have been an afterthought of the trustees, for it is only a few weeks ago since that firm received the commission to carry out the installation. This they have done in a manner which reflects the highest credit on them. As at present arranged, only the principal portions of the establishment on the ground floor will be so illuminated, the rest being supplied with gas, but it is expected that eventually the whole of the building will be lighted by electricity. Provision is made now for between

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600 and 700 incandescent lamps of the Swan-Edison type, of 10, 16, and 32 candle-power, fed by a couple of Edison-Hopkinson dynamos. These were made in America, and are the first of the kid that have been seen in this country, with the exception of the two that have been supplied to the Constitutional Club, now in course of construction in the Northumberland avenue. They are driven by a Davey, Paxman, and Company's horizontal compound engine. The machinery has been fitted up in a building erected on the grounds at a considerable distance from the college, and communicating with the latter by means of a tunnel, through which the leads are conveyed, by the aid of all the necessary appliances for effective insulation, to the main switch-board. From this the subsidiary circuits to the various parts of the building are supplied. A number of these circuits have been provided, no one of them carrying more than 25 amperes. In the tunnel alluded to a small line of rails has been laid for the purpose of carrying to and from the college the household supplies. The small trucks of the miniature line will in all probability be driven by an electric motor. As regards the fittings for the electric light we can speak only in terms of the highest praise. They are models of design and workmanship in brass. Indeed, they are mostly from special drawings from the pencil of the architect, Mr. Crossland, and belong to the pure Renaissance period. The library and museum, which are *en suite*, are furnished with sixteen standards 7ft. high, mounted on marble pedestals 4ft. high Each of these standards weighs over 2cwt. of brass, the whole being finished in gold ormolu. They carry six lamps, each of 32 candle-power, and are the finest and the most elaborate specimens of workmanship of the kind that we have ever seen. The recreation hall is lighted by five electroliers depending from the ceiling, which are also exceedingly elegant in pattern, whilst the brackets in the chapel are in perfect harmony with the richness of the rest of its decorations. In the dining hall there are twelve groups of six lamps each, fixed close to the ceiling, each group being under a celadon reflector. Silvertown wire is used throughout the entire installation, which we have no hesitation in saying, when it is completed, will be not only one of the largest but one of the prettiest in Great Britain.

THE TRANSFORMATION OF HEAT INTO ELECTRICAL ENERGY WITH BATTERIES, THERMOPILES, AND DYNAMO MACHINES.*

With batteries it is the heat generated by the chemical processes going on in them which is transformed into electricity. With thermopiles there is a direct transformation of heat into electricity. With dynamos it is work that is transformed into electricity, and this work is usually done by a steam or some form of gas engine.

In a battery the heat used is the difference of the heat evolved and absorbed in the various chemical actions which go on in it.

Thus, taking a Daniell battery, we have the heat given out in the formation of zinc sulphate mines that absorbed in the decomposition of the electrochemically equivalent amount of copper sulphate, or, what is the same thing, the heat given out in the union of zinc with oxygen minus that given out by the union of copper with oxygen.

We will consider as the available heat only that which is generated outside the battery. Thus, if we consume a certain amount of material in the battery, a certain part of the heat goes to warm the battery itself, owing to its resistance, and this heat is lost and cannot be made to do external work. Thus, if the current be A amperes, and the resistance of the battery R ohms, the work which goes to heat it per sec. is A^2R; and, if E be the E.M.F. of the battery, the work which is done outside the battery per sec. is in electrical units $AE - A^2R$. Now, $A = \frac{E-e}{R+R'}$, where e is the E.M.F. generated by the motion and R' the resistance of the external circuit. The ratio of the heat used in the external circuit to the whole heat given out by the battery, if we do not take into account local action and other causes of waste in the battery, is $\frac{AE - A^2R}{AE}$, or, substituting the above value of A, $\frac{E\,R' + e\,R}{E\,(R+R')}$. If $R = R'$ this becomes $\frac{E+e}{2E}$.

This last ratio is greatest when $e = E$. Then all the heat is used outside the battery; but then there is no current. We see from this that we may increase the ratio of the heat given out in the external circuit to that used in battery by increasing either R' or e; and that theoretically we may use very nearly the whole heat externally. The same reasoning applies to thermopiles and dynamos. In practice, however, there are other things to be taken into consideration. For particular practical cases, taking into account the actual material used up, the author gives the percentage 47·72 for a Daniell and 59·1 for a Bunsen.

In the case of thermopiles the percentage of heat available in the circuit is very small indeed. There we count as the heat employed the heat given out by the fuel actually burnt. For a pile of Rebicek, from data given by Herr Kayser in *Wied. Ann.*, only 0·16 per cent. of the heat. This was for 20 or 25 elements. For 50 large class elements the percentage was only 0·13.

In the case of Clamond's thermopile, taking data from "Müller-Pfaundler's Text-book of Physics," we get 0·057 per cent., and from N. Kayser's experiments 0·076 per cent. A Clamond thermopile heated with coke gives more favourable results. In this case we get 0·518 per cent. of the energy given out by the coke in electrical energy in the external circuit.

In Lord Rayleigh's comparison of a thermo-electric battery, consisting of German silver and iron with a perfect heat engine, he found that the latter would yield 300 times more electric energy than the thermopile.

It seems natural to suppose that the direct transformation of heat into electrical energy should be the most advantageous manner of making this transformation, and that at some future time thermopiles will acquire great practical value. The great waste of heat arises, of course, from the fact that, owing to the smallness of the surface, only a very small quantity enters the pile at all, and some of this passes by conduction to the cold junctions, or is radiated from the external surfaces of the elements.

We now come to dynamo machines, and as a working motor of such we are thinking here of a steam engine or a gas motor, and we shall compare the relations between the useful electric energy imparted to the dynamo machine, and the heat energy given out by the combustible consumed (coal or gas). We must not here alone regard the heat which passes into the water and makes it steam, but the whole heat which is given out by the combustible. We do not concern ourselves with the efficiency of the heat engine, but with that of the apparatus which converts the heat into electric energy, passing over the intermediate transformation.

In the case of a steam engine the calculation gives 3·2 per cent. of the heat used as being converted into electrical energy in the external circuit; in the case of a gas engine 5·85 per cent.

Hitherto we have concerned ourselves with the relation of the quantity of useful electrical energy obtained from the known quantity of heat employed in generating it by different methods, and we have shown that batteries give by far the greatest amount of electrical energy for the same quantity of heat. Thus they give ten times more than dynamo machines, and, if we speak of Clamond's thermopile with coal heating, 200 times more than thermo-electric batteries.

The relations will, however, be different if we have regard to cost. The heat used in batteries is the dearer, because here it is zinc, which is burnt, while in the other cases it is coal or gas. We will therefore look at the relation between the electrical energy obtained and the cost in the three cases.

To have the same relation with all sources, we will take the proposition to determine the cost of an hourly electric energy of 500 volt-amperes as given by batteries, thermopiles, and dynamo machines.

In a Daniell battery we take into account the cost of the zinc and sulphuric acid. The copper vitriol used need not be reckoned, as its cost is covered by the deposited copper.

In the case of thermopiles and dynamos there is the wear and tear of the apparatus, as well as the cost of the combustible used.

The following table gives the expense in the several cases. The wear and tear of the machinery is taken into account in the case of dynamos, but not in the case of thermopiles.

Name of Element.		Cost per hour of 500 volt-amperes.
Daniel Element		1·06 Mk
Bunsen Element		1·51 ,,
Rebicek Thermopile	Starpile	5·65 ,,
	Pile with straight fire-line	7·17 ,,
Clamond Thermopile	with gas-heating	16·03
	with coal-heating	0·42
Dynamo Machines	with steam	0·105
	with gas motor	0·25

These numbers show that the cheapest electric energy is given by dynamo machines which are driven by steam power.

The mark may be taken as the equivalent of 1/-.

* Abstract from an article by Wilhelm Peukert in the *Zeitschrift für Elektrotechnik*.

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SOUTH KENSINGTON.

EXAMINATIONS OF THE SCIENCE AND ART DEPARTMENT.

The following are the questions set in Subject IX., Magnetism and Electricity, at the recent examination; examiners, Prof. Frederick Guthrie, F.R.S., and Prof. G. Carey Foster, F.R.S. :—

General Instructions.—(If the rules are not attended to, the paper will be cancelled).—You may take the elementary, or the advanced, or the honours paper, but you must confine yourself to one of them. Put the number of the question before your answer. You are to confine your answers strictly to the questions proposed. Your name is not given to the examiners, and you are forbidden to write to them about your answers. The examination in this subject lasts for three hours.

FIRST STAGE OR ELEMENTARY EXAMINATION.

(Time: Three Hours.)

Instructions.—You are not permitted to attempt more than eight questions. You may select only two in Magnetism, three in Frictional Electricity, and three in Voltaic Electricity. The value attached to each question is the same.

Magnetism.

1. If a compass needle is deflected when a steel bar is brought near it, how can you find out whether the deflection is due to magnetism already possessed by the bar, or to the bar becoming magnetised by the compass needle at the time of the experiment.

Answer. Bring first one end of the bar, and afterwards the other end, gradually near to the same end of the suspended compass needle. If attraction ensue in one case and repulsion in the other, we conclude that the bar was magnetised previous to the experiment. If attraction ensue in both cases we conclude that the bar was magnetised by the compass needle at the time of the experiment. If the deflection in the first case be a repulsion we may conclude, without further trial, that the bar was previously magnetised.

Remarks. If the bar were merely magnetised by the induction of the compass needle, the magnetising force being so small, the bar would only be temporarily magnetised, and, therefore, in each case the end presented to the compass needle would become oppositely magnetised to the end of the needle to which it was presented.

It is important that the bar should be brought gradually near to the compass needle, for if it were brought suddenly almost into contact with the needle it might, if magnetised so that the adjacent ends of the needle and bar were similar, have its magnetism reversed by the inductive action of the needle, and so show attraction instead of repulsion.

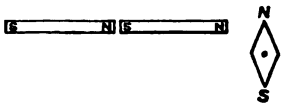
2. Two equal bars of steel, after having been equally magnetised, are kept for some years in a vertical position, one (A) with its south-seeking pole upwards, the other (B) with its north-seeking pole upwards. The bars are so far apart that they do not act on one another; which of the two bars would you expect to find had kept its magnetism best, and why?

Answer. The bar (A) would keep its magnetism better than the other.

For in this country, being entirely to the north of the magnetic equator, the earth's magnetic force acts in such a direction as to make the north-seeking end of a freely suspended magnetised bar dip downwards towards the horizontal, at an angle called the angle of dip, which varies from place to place, and it would act in the same way on the molecules composing the two bars, tending in each case to produce a north-seeking pole at the lower end of the bar and a south-seeking pole at the upper end. Thus the earth's action would assist (A) to retain its magnetism, but would tend to reverse the magnetism of (B).

3. You have given to you two rods, one of soft iron, the other of hard steel; also a compass needle and a bar magnet. Describe experiments with the things provided whereby you could find out which was the iron and which the steel rod.

Answer. Lay the bar magnet on a table, and place one of the bars to be tested close to, or even in contact with, the magnet S N, and in the same straight line with it. To the end of the bar remote from the magnet bring near the end of the suspended compass needle similar to the pole of the magnet adjacent to the bar; observe whether the compass needle be attracted or repelled. Now, without removing the bar magnet or the compass needle, replace

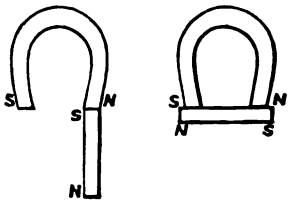


the first bar by the second, and again observe whether attraction or repulsion ensue.

It will be found that in one case there will be attraction and in the other repulsion. The one which attracts the needle will be the bar of hard steel, and the one which repels it will be the bar of soft iron.

Explanation. The soft iron becomes magnetised by induction while in the presence of the bar magnet, but the effect of the bar magnet on the hard steel will be very small, extending only to the molecules of the bar in immediate proximity to the magnet, and therefore the bar remains practically unmagnetised.

4. A piece of soft iron, placed in contact with both poles of a horse-shoe magnet at the same time, is held on with more than twice the force with which it would be held if it were in contact with only one pole of the same magnet. Why is this?



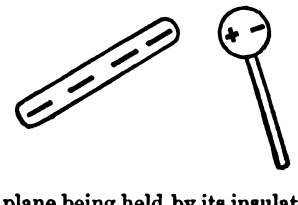
A.—When the piece of soft iron is placed in contact with one pole of the horseshore magnet it becomes magnetised by the induction of the pole with which it is in contact. When the piece of soft iron is in contact with both the poles of the horseshoe magnet it is subject to the inductive action of both the poles of the magnet, and becomes more strongly magnetised. The force with which it is attracted by each pole is therefore greater than that with which it was attracted by the single pole in the first case, so that the whole force of attraction of the two poles on the soft iron bar is more than double the force of attraction of the single pole.

Frictional Electricity.

5. A stick of sealing wax, held in the hand and rubbed with dry flannel, is found to become electrified. A brass rod after being treated in the same way shows no electrification. How do you account for the difference?

A.—The stick of sealing wax is a bad conductor of electricity, and therefore the electricity produced upon its surface is retained. The brass rod, on the other hand, is a good conductor, and being in contact with a portion of the human body, which is also a conductor, the electricity flows away as fast as it is produced upon the surface of the rod.

6. A stick of sealing wax, having been rubbed with flannel, is found to be negatively electrified. How, by means of it, would you charge a proof plane with positive electricity?



A.—The proof plane being held by its insulating handle, bring the negatively electrified sealing wax close to its metallic portion (or even in actual contact with it, for the sealing wax being a non-conductor, will not part with an appreciable quantity of its electricity to the proof plane). The proof plane then becomes electrified by induction, positively on the side near the sealing wax, negatively on the further side.

Connect the proof plane while in presence of the sealing wax to the earth by touching it with the finger, or otherwise, in order to remove the negative electrification, and remove the finger. If the proof plane be now removed from the inductive action of the sealing wax it will remain positively electrified.

7. If an electrified piece of metal is made to touch a gold leaf electroscope, the leaves separate, and, on taking the metal away, they remain separate. But if the electrified metal is only brought

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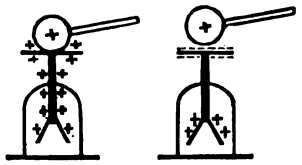
near to the electroscope, and then taken away, the leaves separate when the electrified metal is near, but fall together when it is taken away. Why is there a lasting effect on the gold leaves in one case and only a temporary effect in the other case?

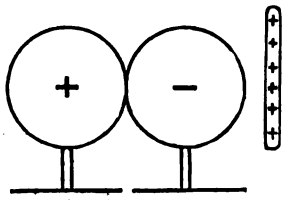


A.—In the first case, the electrified piece of metal (which must, of course, be held by an insulating handle) communicates, by conduction, a portion of its charge to the electroscope, and the charge so communicated to the electroscope remains after the piece of electrified metal is removed.

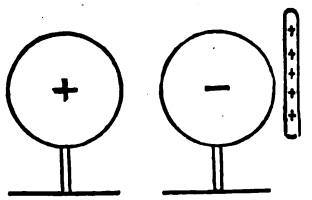
In the second case, the plate of the electroscope and the upper part of the metal rod which carries the gold leaves become, by the inductive action of the piece of electrified metal, oppositely electrified to it, while the gold leaves and the lower part of the rod become electrified similarly to it. The electroscope, however, receives no absolute charge, and therefore the leaves fall together again when released from inductive action by the removal of the electrified body.

The figure is drawn for the case of positive electrification of the piece of metal.

8. Two insulated metal spheres are brought so as to touch one another. A positively electrified glass rod is brought near to one of the spheres, and, while it is there, the other sphere is taken away. The glass rod is now taken away. On bringing the spheres near together again, a spark passes between them. Give the reason for this.



A.—By the inductive action of the positively electrified glass rod the nearer sphere becomes negatively electrified and the further one positively.



If the spheres be so parted while under the inductive action of the glass rod, and the rod then removed, their electrifications remain unchanged.

If the spheres be now brought together in the absence of the glass rod, there will be, since they are oppositely electrified, a discharge of electricity from one to the other, which accounts for the park.

9. To protect a gold-leaf electroscope from being acted on when an electrical machine is at work near it, it is sufficient to cover the electroscope with a thin cotton cloth. How is this?

A.—Since the electroscope is protected from the inductive action of an electrical machine near it by covering it with a cotton cloth, the cloth must be a conductor, as would be the case unless it were perfectly dry, and then it would not protect the electroscope from the action of the machine.

The electroscope may therefore be considered as enclosed within a hollow conductor, and the electricity upon a hollow conductor under the inductive action of *external* electrified bodies distributes itself upon the surface of the conductor in such a manner as to exert no electrical action upon any bodies enclosed within it.

Remarks. We may note that, whether the enclosed bodies be in electrical communication with the hollow conductor or not, they will be protected from the action of any electrified bodies external to the hollow conductor, and we also know that, even if an absolute charge were given to the hollow conductor by conduction from any electrified body, the charge so given would also distribute itself over the surface of the conductor in such a manner as to exert no electrical action upon bodies enclosed within it.

(To be continued.)

CRICKET.

EASTERN TELEGRAPH COMPANY v. ANGLO-AMERICAN TELEGRAPH COMPANY.

The second of the Inter-Telegraph Companies' cricket matches came off on Saturday last at Brockley, and resulted in an easy victory for the Eastern Telegraph Company. Very little description of the play is needful. The Anglo Company, having won the toss, decided to go in first, but were unable to make any stand against the very fine bowling of Messrs. J. G. McMillan and Alexander Jack, the former securing seven wickets in six overs at a cost of two runs. This is really fine bowling. Mr. McMillan deserves full credit for his performance. The innings closed for eight. After a short interval the Eastern Company commenced their innings with Messrs. Palmer and McMillan, who very soon put the result of the match beyond a doubt. Messrs. M'Donald, Captain Greey and Couper, all batted well, and the innings closed for 77. The Anglo Company then went in for their second innings, and after about an hour's play were disposed of for 27 runs, Mr. Couper being the most successful bowler. Messrs. Langley, A. Duncan, and Edwards were the only ones who made anything of a stand, contributing the best part of the 27 runs for which the innings closed. This left the Eastern Company victors by an innings and 42 runs. The following is a detailed list of the scores:—

ANGLO-AMERICAN TELEGRAPH COMPANY.—*First Innings:* A. J. Willis, c. Gray, b. McMillian, 0; G. Duncan, b. McMillan, 0; A. Duncan, b. McMillan, 0; R. J. Edwards, b. McMillan 0; S. R. Bartrum, b. McMillan, 0; H. Bergamin, b. McMillan, 0; C. C. Afflex, b. A. Jack, 1; J. Mountford, b. A. Jack, 1; A. G. Reynolds, b. A. Jack, 0; C. W. Langley, c. Grey, b. McMillan, 0; F. Green, not out, 1; extras, 5. Total, 8.—*Second Innings:* A. J. Willis, c. A. Jack, b. Couper, 0; G. Duncan, b. A. Jack, 3; A. Duncan, b. Couper, 4; R. T. Edwards, c. Couper, b. McMillan, 6; S. R. Bartrum, b. Couper, 1; H. Bergamin, c. Greey, b. McMillan, 0; C. C. Affleck, b. Couper, 0; J. Mountford, b. A. Jack, 2; A. G. Reynolds, b. Couper, 1; C. W. Langley, c. Green, b. McMillan, 7; F. Green, not out, 0; extras, 3. Total, 27.

EASTERN TELEGRAPH COMPANY (LIMITED).—*First Innings:* J. G. McMillan, b. Duncan, 10; T. J. Palmer, run out, 4; C. Hensman, b. Duncan, 2; G. McK. Munro, c. Willis, b. Duncan, 6; W. Macdonald, b. Reynolds, 22; Capt. R. Greey, b. Reynolds, 14; G. C. Jack (captain), l.b.w., b. Duncan, 0; W. Couper, l b.w., b. Affleck, 14; T. Richardson, b. Affleck, 0; A. Jack, c. Reynolds, b. Affleck, 0; E. D. Payne, not out, 0; extras, 5. Total, 77.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. JUNE 23.		BUSINESS DONE WEEK ENDING JUNE 23. Highest.		Lowest.	
Anglo-American	32,	33		32¼		32
Do. Preferred	53½,	54½		53½		53½
Do. Deferred	10⅞,	11¼		10⅝		—
Brazilian Submarine	10½,	10¾		10 11-16		10¾
Cuba	10¼,	10⅝		10 9-16		10½
Do. Preference	18½,	19½		18½		—
Direct Spanish	1½,	2		—		—
Do. Preference	9,	10		—		—
Direct United States Cable	9,	9¼		9⅜		—
Eastern Telegraph	10⅝,	10⅞		10⅞		10⅝
Do. 6 per Cent. Preference	14¼,	14½		14½		14¼
Do. 5 per Cent. Debentures, 1899	105,	108		—		—
Eastern Extension	12⅛,	12⅜		12⅜		12⅛
German Union	9¼,	9½		—		—
Globe Telegraph and Trust	6¼,	6½		6⅝		6⅜
Do. Preference	13⅛,	13⅜		13 5-16		13⅛
Great Northern	12,	12½		12⅝		12½
Indo-European	34,	35		35		34½
Reuter's	6,	6½		—		—
Submarine	200,	210		—		—
West India and Panama	⅛,	¼		9-16		—
Do. 1st Preference	8,	8½		—		—
Western Brazilian	7⅛,	7⅜		7¼		—
Western Union 7 per Cent. 1st Mortgage	118,	122		—		—
Do. 6 per Cent. Sterling Bonds	103,	107		—		—

TELEPHONES.

Consolid. Telephone and Maintenance	13-16	15-16		⅞		—
Oriental	3-16	5-16		—		—
United Telephone	13⅛,	13⅛		13 13-16		13⅛

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	2,	2¼		2 5-16		2
Do. (fully paid)	4,	4¼		3⅞		—
Swan	1½,	1⅝		1⅝		1 9-16
Maxim-Weston	3-16	5-16		¼		—

MISCELLANEOUS.

Telegraph Construction	39½	40½		39½		38⅝
India Rubber, Gutta Percha, and Telegraph Works	22½	23½		23½		23 3-16

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NOTES.

PERSONAL.—Mr. Sydney Evershed has joined the staff of Messrs. Goolden and Trotter, electricians, Westminster.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 25th ult. amounted to £2,661.

ELECTRO-PHOTOGRAPHY.—M. Tommasi has found that the silent electric discharge produces the same effect upon sensitive photographic plates as do the ultra-violet and violet rays of light.

ELECTRIC TRAMWAYS.—Owing to the success of the Blackpool tramway, a company is in active formation for working Mr. Holroyd Smith's patents relating to the electrical working of tramways.

SWISS EXHIBITION.—It is proposed to hold next year at Geneva, on the occasion of the federal shooting competition, an exhibition devoted to electrical science and to the decorative and fine arts.

ELECTRIC LIGHT IN FRANCE.—At Bourganeuf, near Brest, the electric light has recently been introduced. The motive power is supplied by water, the installation giving the greatest satisfaction to the inhabitants.

TELEGRAPHIC TARIFF.—The French Senate on Tuesday approved the Telegraphic Tariff Convention concluded at Berlin on 9th September, 1885, and the Anglo-French Telegraphic Arrangement of 11th May last.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 25th ult. were £2,049, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

THE MIRROR GALVANOMETER.—The *Centralblatt für Elektrotechnik* complains that in the Catalogue of the Inventions Exhibition Dr. Lodge attributes the invention of the mirror-galvanometer to Sir W. Thomson. It claims this invention for Gauss.

ELECTRIC LIGHT AT EASTBOURNE.—Tenders are being invited by the town council for electric light and gas fittings for the new town hall. Persons wishing to tender are to send their names to the architect, Mr. W. T. Foulkes, 100, Colmore-row, Birmingham, by 15th July.

A SIGN OF THE TIMES.—Last week the Lanark Town Council, which is one of the largest shareholders in the Lanark Gas Consumers Company, decided to oppose a proposal to erect a new gasholder at a cost of £1,200, on the ground of the extension of electric lighting in this country.

A NEW TELEGRAPH LINE.—A new line has just been built in the Republic of Colombia between the cities of Manizales (State of Antioquia) and Cantago (State of Cauca), which gives communication to two other cities; but the most important feature is that it opens two routes from the capital to the cable line at Buenaventura.

SOCIETY OF ARTS.—The Society of Arts *conversazione* will be held, by permission of the Royal Commission, at the Colonial and Indian Exhibition, South Kensington, on Friday, the 16th July. There will be no admission to the Exhibition on this evening, except by special ticket, and no tickets can be purchased at the Exhibition.

ELECTRIC LIGHT IN LEEDS.—Mr. Wilson Hartnell, of Leeds, has obtained an order to light by electricity the large flour mills of the Leeds Industrial Co-operative Society. The installation will consist of 200 incandescent lamps, with fittings of the latest type. Another order has been secured by Mr. Hartnell for an installation at Dewsbury, where the Otto gas engine will be the motor.

NEW ELECTRIC TRAMWAY CAR.—Experiments are being made at the Schwortzkopff Works, in Berlin, with a new electric tramway car. The batteries are placed before and behind the platform, and take up little space, so that there is plenty of room for standing. The car has eight wheels, which is rather a disadvantage in getting over curves, but the trials so far have had good results.

STREET OWNERSHIP.—A New Orleans paper says that street car companies own only the surface of such streets as they choose to occupy. Below the surface, gas and waterworks companies are the sole proprietors. Above, the wire concerns —such as telegraph, telephone, and electric companies—are supreme. Any other odd space that may happen to be about is used by the city for storing dirt.

CABLE BETWEEN CANADA AND AUSTRALIA.—Instructions have been sent (says *The Times*) by the Dominion Government to Sir Charles Tupper, the High Commissioner for Canada in London, to confer with the Australian Agents-General concerning the establishment of cable communication between Australia and the Canadian Dominion, and to ascertain the amount of the annual subsidy which the colonies would guarantee.

ELECTRIC LIGHT IN PARIS.—The members of the Congress of the Société Technique de l'Industrie du Gaz have recently been paying a visit to the laboratory of the electric installation in the Rue Appert, Paris. M. D. Monnier conducted the visitors through the building, and they were loud in their praise of the Edison lamps, as well as of the Cance arc lights, the absolute steadiness of which they were obliged to acknowledge.

LIGHTING AT THE ROYAL BOTANIC SOCIETY'S FETE.—On Wednesday last, at the annual *fête* of the Royal Botanic Society, Regent's Park, a dining table was shown by Dick Radcliffe and Co. having a miniature lake in the centre, with fountains playing, and water lilies carrying small incandescent lamps. Tiny lamps were also distributed about the moss in a grotto, simulating glowworms. The current was supplied by a primary battery.

FRICTIONAL ELECTRICITY.—A suggestion has been made to utilise the electricity so freely obtained in many industrial operations by means of a secondary generator. The electricity is to be collected by means of brass points connected to continuous or Leyden jars, from which it is discharged through a long coil of fine wire, forming the primary, the secondary being of thick wire from which it is hoped to get the electricity for use at a low potential.

NEW AUTOMATIC SWITCH.—M. Allard, secretary to the Belgian Electrique Company, who invented the switch for putting into circuit any given number of secondary batteries, so as to regulate the speed of the electric tramcar, is now perfecting an automatic switch for instantaneously throwing into circuit the current from secondary batteries on that from a dynamo being thrown out. In the case of electric lighting, the interruption is so momentary as scarcely to be noticed.

BLACKPOOL ELECTRIC TRAMWAY.—The audit of the books shows, for the half-year ending with May, that the working expenses are only half that of horses on the most economically worked lines, even allowing 10 per cent. for interest on capital, and 15 per cent. for depreciation, because all the generating plant is duplicated. If the electrical working of the Blackpool tramway be compared with the working by horses before the

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electrical plant was ready, it will be found to cost only 25 per cent. of the latter.

LABORATORIES FOR PARIS.—The International Society of Electricians has decided upon building laboratories for the use of physicists in Paris. They will be established in the grounds of the old Collége Rollin, granted by the City of Paris, in the vicinity of the school of Practical Physics, recently erected by the Municipal Council. The funds will be supplied by public subscription, a contribution from the society, and a sum of 360,000 francs, which is the surplus of the last electrical exhibition organised by M. Cochery.

THE PATENT OFFICE LIBRARY.—We are requested to state that the Free Public Library, at the Patent Office, 25, Southampton-buildings, Chancery-lane, W.C., is now open to the public daily from 10 a.m. to 10 p.m., instead of, as heretofore, from 10 a.m. to 4 p.m. This library, in addition to the specifications, indices, and other publications of the Patent Office, contains a large collection of the leading British and Foreign scientific journals, *transactions* of learned societies, and text books in the various departments of science and art.

LONG LIFE OF INCANDESCENT LAMPS.—The longevity of the Swan incandescent lamps on the Great Eastern Company's steamer, "Norwich," has already been referred to. Unfortunately, the lamp which the chief steward placed in his cabin for observation has been broken by accident; but there are some in the saloon burning as brightly now as when they were first placed there three years ago, having lasted over six thousand hours of actual use. Moreover, not a switch has given out, even those placed in the cabins at the command of passengers.

ELECTRICITY ON THE STAGE.—In the second part of "Faust" the Homunculus, as is known, presents himself. Earlier this being was painted on a glass bottle, in which a petroleum lamp burnt. Now they have made trial of an electric Homunculus at the Court Theatre in Hanover. The body is formed out of transparent red silk, and is illuminated by two little incandescent lamps, one of which is in the head. A little six-celled chromic-acid battery, fastened under the glass globe, serves as the source of the current. The effect is much better than with the old contrivance.

DOMESTIC LIGHTING IN BRUSSELS.—The Belgian "Electrique" Company has taken over the premises in the Rue Zérézo, lately occupied by the Societé Générale d'Electricité, which will in future direct its energies chiefly to lighting in the provinces of Belgium. The "Electrique" Company, whose tramcar worked by accumulators took the first prize at the Antwerp trials, has arranged to light several *cafés* and private houses in a whole district near the Northern Terminus. At present contracts are made in each case; but, after the first year's working, the current will be charged by meter.

LIGHTING OF THE GRAND' PLACE AND HOTEL DE VILLE, BRUSSELS.—On Saturday the Belgian Society of Engineers visited the temporary installation for lighting portions of the Hôtel de Ville, when they were made acquainted with the comprehensive scheme for illuminating the whole of that magnificent Gothic pile, and also the Grand' Place adjoining. The latter is now lighted on alternate evenings by two arc lamps mounted on high masts, and by two clusters of intensive gas lamps; but even gas engineers acknowledge that the former is more effective, while it seems that the difference in cost is not great.

SHIP LIGHTING.—On account of the appreciation by the passengers of the incandescent lighting on the Great Eastern Company's steamers "Norwich" and "Ipswich," two more of their vessels, the "Adelaide" and the "Claude Hamilton," have lately been fitted throughout with incandescent lamps driven by Crompton dynamos; and the "Princess of Wales" and "Lady Tyler" are to be similarly treated. A new twin-screw steamer, to carry 475 passengers, is being built for the Great Eastern Company by Earle's Shipbuilding Company at Hull, and is to be lighted fore and aft on the incandescent system.

AMPÈRE'S RULE.—In a letter to the last number of our contemporary, *Nature*, Mr. G. Dähne, of Dresden-Striesen, says:—"There is another rule, published by Pfaundler, if I am not mistaken, which is far simpler, as it does not compel the imagination to fancy movements and actions of the human body which it in reality never could perform:—'Follow the direction of the current in moving the right hand along the wire, but holding it so that the stretched fingers are parallel to the wire, and the palm is turned towards the north pole of the magnet. The outstretched thumb then gives the direction in which the north pole will be deflected.'"

KILLING DOGS BY ELECTRICITY.—Under this title, the *Electrical World*, of New York, describes a method adopted by the Kimberley Borough Council, on the recommendation of their electrician, Mr. R. L. Cousens, for despatching unclaimed dogs in a more painless manner than by poison. The dog is put into a box, with the fore paws on one moistened copper plate, and the hind paws on another. The plates are put in the circuit of a Brush dynamo, which maintains some electric lamps. When the box is closed, the current is sent through the dog, killing him instantaneously. On one occasion 23 dogs were killed in less than the same number of minutes.

ST. VINCENT.—A valued correspondent writes:—"Things every day getting more civilised at St. Vincent. Not only does the telegraph staff, which, by the way, numbers on its rolls seventeen fine healthy young fellows, possess a lawn tennis court, a theatre, a number of horses from the neighbouring island of St. Thiago, and a sanatorium perched high on the mountain, but an enterprising firm, Messrs. Miller, have introduced the electric light on their coal wharves. I could learn no particulars of the installation owing to the exigencies of time, but the light shone out over the bay at night with great effect, quite eclipsing the feeble ray from the lighthouse on Bird Rock."

LIGHTING IN SWEDEN.—We learn from *L'Ingénieur Conseil* the following particulars of the lighting arrangements for the little town of Hernosand, in the North of Sweden. The installation is proportional to the number of inhabitants—only 4,000; but it is encouraging to find such enterprise in so small and out-lying a town, situate on an island in the Gulf of Bothnia. A Thomson-Houston dynamo is driven by a waterfall about two miles from the town, and maintains 27 arc lamps of 1,200 candle-power each. The whole installation cost £1,120; and, estimating at £100 per annum the expenses of maintenance and supervision, the saving will be 25 per cent. of the former cost for lighting.

ELECTRIC LIGHTING IN BRUSSELS.—The old Temple des Augustins, which will continue to be used as the central Post Office until the new building begun on the site of the former Mint is completed, has, since Saturday last, been lighted by four arc lamps, two sun lamps, and several incandescents. The dynamo is driven by a 46 horse-power compound engine, with steam reservoir and Rider gear, made by Bollinckx et Cie, of Brussels. They are largely using this type of engine for electric lighting, and, strange to say, have gone back to the old Watt governor, but with extra heavy balls, finding that it

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preserves a more constant speed than many of the newer governors.

LONG DISTANCE TELEPHONY.—M. Van Rysselberghe is now taking a well-earned rest in Brussels from his labours in establishing telephonic communication at long distances on the American Continent, whither he will shortly return. He has succeeded in holding distinct conversation between Buenos Ayres and Santa Fé, a distance of 500 kilometres, or 310 miles; between Santa Fé and Martin Garcia, 570 kilom., or 353 miles; Buenos Ayres and Rosario, 350 kilom, or 217 miles; as well as many other lines of less distance. Except in the Santa Fé and Martin Garcia line, 50 kilometres, or 31 miles, of which is a submarine cable, the persons conversing were able to distinguish each other's voices.

SALE OF ELECTRICAL PLANT.—We have received from Messrs. Wheatley Kirk, Price, and Goulty, of 52, Queen-Victoria-street, a catalogue of the electrical plant and fittings forming the surplus stock of the Edison and Swan United Electric Light Company (Limited), to be sold by auction at 67A, Cow Cross-street, E.C., on the 7th, 8th, and 9th inst., consequent upon the removal of the manufacturing department of the company from Newcastle to the metropolis, and their change of offices from Holborn to 14, Albert-mansions, Victoria-street, S.W. Electricians, ship owners, engineers, &c., will find at the sale every species of electrical apparatus, and will doubtless carry off some cheap purchases.

A RAPID INSTALLATION.—At the Grand Hotel, Brussels, recently, M. Allard, secretary to "L'Electrique" Company, asked some friends to join him at dinner. They knew he was not lighted electrically, and accepted on condition that the dining room should be so illuminated. He accepted the condition, though it was then a quarter past four, and the dinner was fixed for half-past six. He telegraphed to the works for a dozen 5-kilo. Julien accumulators, weighing together 60 kilogrammes, or 132lb., with instructions for a man to rig up six 10-candle lamps on the gaselier, with the leads of course anyhow. The guests were taken aback on entering to find the *salle à manger* brilliantly illuminated with an installation good for ten hours.

TELEPHONE CHARGES.—A meeting of business men, says the *Manchester Examiner*, was held on June 24 at the Manchester Cotton Waste Exchange to consider the charges of the Lancashire and Cheshire Telephonic Exchange Company. It was stated that subscribers had two grievances—firstly, that the present subscription of £20 was too high; and, secondly, that the company were now enforcing an additional subscription of a guinea a year for the use of the telephone boxes on the Exchange. The formation of a new company, on the system of Prof. Thompson, was suggested by the chairman, Mr. George Hahlo. A committee was appointed to lay the views of the meeting before the directors of the company, and to take such action as was deemed necessary.

NEW RESISTANCE SWITCH.—The difficulty connected with resistance coils lies in the fact that when they are used in series, and only a small final resistance is required, while large currents are employed, the passage through a short resistance tends to overheat it. If used in parallel, in order to obtain a large resistance through a single coil, a considerable number and weight of coils must be employed. Mr. Holroyd Smith has devised a switch whereby the same coils with the same terminals and continuous movement in the same direction may be used first in series and then in parallel, or *vice versâ*. If the switch be employed for putting in resistance, the coil is used first in parallel and then in series; but, if for taking out resistance, first in series and then in parallel.

ELECTRIC TRACTION.—Writing on this subject, our contemporary, the *Echo*, says: "The mischief done by the unwise rush for speculating schemes in connection with new inventions is well exemplified by the present position of practical electricity. Capitalists will not look at schemes for electric lighting, a department in which they have been severely bitten, and they carry their dislike into other departments, and will not support schemes for providing electric traction, preferring, rather, to support the 'cable' tram lines. Yet, while electric lighting, so far as the public service is concerned, never had much chance in this country, with gas at three shillings, it is probable that electric traction would pay well on many tram lines; certainly it is more promising than the resuscitated cable system."

AN ELECTRIC LOCOMOTIVE.—Messrs. E. M. Bentley and W. H. Knight have designed an electric locomotive for light passenger work, to be constructed at the Rhode Island Locomotive Works, U.S.A. The *Electrical World* says that it is of standard gauge, has a 12ft. wheel base, and weighs about 22 tons, the weight being evenly distributed over the six 68in. wheels. The motor armatures, 36in. in diameter, exert a force of 500,000 watts upon the wheels, which are all coupled, without the intervention of gearing. The engine is fitted with electric head lights, bells, and brakes, in addition to electric connections for incandescent lamps and continuous brakes throughout the train. It has no reciprocating parts, and is equally well adapted for use with overhead, surface, or sub-surface connection with the central power station of the line.

THE TELEPHONE IN SOUTH AFRICA.—In St. Paul de Loanda, the capital of the Province of Angola, a Portuguese possession on the South West Coast of Africa, there is an excellent and economical telephone system. The whole of the Government offices and a number of private houses are connected with a central office and with the terminus of the telegraph system, which penetrates some 200 miles into the interior. The telephone apparatus used is a modification of the Blake transmitter and Bell receiver; and the prices charged are very moderate, *i.e.*, about £4. 10s. for installation, and about £6 per annum subscription. The system works very well indeed, and is highly appreciated by those who had formerly to employ the expensive Maxilla as a means of locomotion, or plod through the sand-laden streets of Loanda. There are already sixty-one subscribers.

SOLID ELECTROLYTES.—At the meeting of the Physical Society, held on June 12, a voltaic cell with a solid electrolyte was exhibited by Mr. Shelford Bidwell. Its construction is as follows:—Upon a plate of copper is spread a layer of quite dry precipitated sulphide of copper; if on this a clean plate of silver be placed, and the cell joined up to a galvanometer, a slight deflection is observed due to the unavoidable presence of moisture. If, however, the silver plate be covered with a slight film of sulphide of silver, by pouring on it a solution of sulphur in bisulphide of carbon, and evaporating the free sulphur by heat, and then placed with the prepared side down as before, a deflection is obtained far greater than, and in the opposite direction to, the former. The resistance of the cell was very great, but was enormously reduced by compression. The E.M.F. was about ·07 volt.

TELEGRAPH POLES. — Mr. Greenhill, in a paper on "Creosoting," read before the Institution of Civil Engineers, Ireland, gives the following information as to the system for the preservation of telegraph poles for Government. Creosoting is universally adopted, all other systems having fallen into disuse. It is reported that, to obtain the specified quantity of 10 pounds of creosote injected per cubic foot, the fine skin

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which grows upon the pole just underneath the bark must be carefully removed by planing. Native larch and other timber is reported to have failed, and no other timber but Baltic red-wood well seasoned and then creosoted is used. All the sundry processes for the treatment of timber with salts of zinc, copper, and mercury seem to have fallen into disuse owing to the corrosion of the receiver and apparatus by the materials employed, a defect not possessed by creosote, and also to the solubility in water. Oil paint in many cases, when used out of doors, conceals rather than prevents decay.

THE TELEPHONE IN TROWBRIDGE.—The New Telephone Company (Limited) have, according to the *Trowbridge Chronicle*, completed their labours in fixing the telephone to Mr. W. Walker's mills, whereby the four mills in different parts of the town are now all connected. "The telephone is Prof. S. P. Thompson's patent, and, unlike other companies, this company sell theirs outright, demanding neither rentals nor royalties; and this system enables persons to talk through miles of line. The wires are carried over the streets on properly insulated supports, and connect the four mills in telephonic communication with each other. We had an opportunity of testing the installation, and could converse freely from the Home Mills to either Yerbury-street, Duke-street, or the Stone Factory; in fact, the articulation was so clear that we could tell who we were conversing with. The entire arrangements have been carried out by Mr. Samuel Diplock, engineer, of London and Trowbridge, who, we understand, has other contracts to carry out under the same system."

BLEACHING BY ELECTRICITY.—This process, which has been brought to commercial success by M. Hermit, is about to be introduced into this country by the inventor, who has appointed as his sole licensees Messrs. Paterson and Cooper, who are commencing the manufacture of the requisite plant on a scale commensurate with the expected demand from the bleaching works of the United Kingdom. One great advantage claimed for the electric process is that a saving in cost is effected of about 50 per cent as compared with the use of bleaching powder, and another is that it does not involve that danger to the tissues operated upon which exists in the present system owing to the presence of lime in the bleaching solution. The working of the apparatus is also very simple, and by means of an ammeter and voltmeter it can be regulated and controlled at any distance from the bleaching tanks. A solution of chloride of magnesium is submitted to the action of an electric current with an E.M.F. of 4 volts through platinum electrodes, causing chlorine to be liberated, and at the same time oxygen from the water, a cycle of changes taking place which ultimately result in the regeneration of the chloride of magnesium.

SHAVER'S MECHANICAL TELEPHONE.—Mr. George F. Shaver has established an exchange station at New York in accordance with his system of mechanical telephony. On entering the station the line is split, one branch being attached at each hole round the bottom of a circular rack, where it is permanently fixed. The other branch of the same line is then attached to a small block placed directly over the lower terminals, and capable of sliding freely up and down between the vertical rods. All the upper terminals are at the same height when the lines are not in use; and it is only when cross connection is made between any two of them that the blocks are lifted to the height of the arm carrying the pulley for tightening the connecting wire. The work of the operator in communicating with the subscriber is facilitated by the use of hand telephones, provided in the rear with two brass strips, hooked at the top so that the instrument can be hung at any point upon a circular hoop running round the interior of the frame. The diaphragm has attached to it a small length of wire hooked to the terminal of the line; and the operator, by gently pressing forward the handle of his telephone, creates a tension on the diaphragm which allows him to communicate with the subscriber. Though some of the lines are about three-quarters of a mile long, the articulation is said to be very satisfactory.

COST OF ELECTRIC LIGHTING.—Writing to a recent number of the *Revue Industrielle* on this subject, M. Delahaye gives some interesting facts. He says that at the Essones paper mills there are 300 Edison lamps of the "A" type, driven by steam power, and the cost per lamp per hour is declared to be not more than 0·0175fr., in consequence of which the mill-owners have decided to discontinue the use of gas. In another paper mill in Central France, possessing water power, the cost of incandescent lighting for the past eighteen months has been determined to be 0·0103fr. per lamp per hour. Upon this basis the incandescent electric lighting in question compares with gas at about 10c. to 15c. per cubic metre, or 2s. 3d. to 3s. 4½d. per 1,000 cubic feet, which is considered to be an unremunerative price for French provincial gas supply. M. Delahaye is very sanguine of even obtaining better results. If the new Edison 2·5-watt lamps are practically successful in working, he points out that a horse-power will supply 14 lamps of 20 candle, instead of as now only eight lamps of 16 candle-power. A Russian electrician, M. Lodyguine, is also reported to have made lamps yielding a candle-power for every 1·6 watt of electrical energy. At this rate a horse-power should supply a score of lamps of 20 candle illuminating value. M. Delahaye is not quite satisfied that the new pattern lamps of which he speaks will really do all this; but he says that they may do so.

ELECTROLYSIS.—At the last meeting of the Chemical Society a paper was read by Prof. H. McLeod, F.R.S., on "The Electrolysis of Aqueous Solutions of Sulphuric Acid, with special reference to the forms of Oxygen obtained," of which the following is an abstract:—"The experiments were instituted to determine the quantity of ozone that can be obtained by electrolysis. The negative electrode consisted of a small platinum plate, and the positive of a tube containing mercury and with fine platinum wires of 0·45 mm. and 0·027 mm. in diameter fused into the glass. Several wires were used, the total length being about 6 mm. The electrolysis was carried out in a U-tube surrounded by ice and water; the hydrogen was collected over water, and the ozonised oxygen passed through a tube containing a solution of potassic iodide, the oxygen being afterwards collected. The quantity of ozone was determined by acidifying the potassic iodide solution and decolorising by a standard solution of sodic thiosulphate. In the electrolysed acid an oxidising substance is present which is not hydroxyl, but is probably Berthelot's persulphuric acid. The amount of this 'active oxygen' was found by adding potassic iodide to the liquid and decolorising by the solution of thiosulphate. The electric current was measured by a tangent galvanometer, and the dimensions of the wires of the positive pole were determined; from these data the intensity of the current was calculated. Acids were used of relative densities varying between 1·025 and 1·7. The maximum quantity of ozone was obtained with solutions about 1·075 or 1·1 in density, the electrolytic oxygen containing about 16 or 17 per cent. of its weight of ozone. The maximum quantity of 'active oxygen' in the oxidising substance referred to was produced with acids about 1·2 to 1·25 in density, the proportion being 16 or 17 atoms to 100 atoms of hydrogen."

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CYRUS FIELD V. LABOUCHERE.—The action which was brought by Mr. Cyrus Field against the proprietor and editor of *Truth* for libel, has, fortunately for both parties, terminated amicably. The libel and inuendos were set forth in the plaintiff's statement of claim as follows:—"At a meeting of the company" (meaning the Anglo-American Telegraph Company, Limited), "held last week, Mr. William Abbott moved that Mr. Cyrus Field should not be re-elected. This worthy philanthropist, it would appear, was concerned in the issue of the Wabash Preference Stock, on which shares dividends were paid until the British public had been induced to buy it, when they fell from 92, the issue price, to about 12. According to the American newspapers Cyrus Field has made by the operation about £1,000,000. Under these circumstances Mr. Abbott was right in opposing the re-election of this gentleman." The case was heard before Mr. Justice Denman and a special jury. Sir Henry James, Q.C., and Mr. Pollard were counsel for the plaintiff; and the Attorney-General (Sir Charles Russell, Q.C.), Mr. Crump, Q.C., and Mr. E. Hume Williams appeared for the defendant. Sir Henry James opened his case in an able speech, in which he met the allegations contained in the libellous paragraph with a direct denial. He further pointed out that Mr. Field's only object in bringing the action was to clear himself from the imputations cast on him, and that, the defendant having withdrawn all the imputations, the parties had agreed that a juror should be withdrawn, and the plea of justification struck out. The Attorney-General said that Sir Henry James's case was that Mr. Field had had nothing to do with the transactions in question, but did not deny that such had taken place. On inquiry Mr. Labouchere had found out that Mr. Field's connection with the company had ceased before any of the Wabash Preference Stock was issued. The statement was made on the authority of Mr. Abbott. Sir Henry James then said that Mr. Abbott, when his attention was called to the statements, wrote withdrawing those he made at the meeting of the Anglo-American Telegraph Company. His lordship assented to the course proposed by the learned counsel. A juror was accordingly withdrawn and the case settled.

THE SOCIETY OF TELEGRAPH-ENGINEERS.—The members and friends of this society, invited by its president, Prof. Hughes, F.R.S., and Mrs. Hughes, held a *conversazione* in the rooms of the Royal Institute of Painters in Water Colours, Piccadilly, on Tuesday evening 29th inst. A very large company of ladies and gentlemen were presented, and during the whole three hours, from nine till midnight, the rooms were crowded by a brilliant array of beauty and learning. It is the first time the society's annual gathering has taken place in the rooms of this institute, on whose walls the display of a vast collection of water-coloured drawings of unique interest added greatly to the charm of the scene and the pleasure of the visitors. Among the visitors present were:—Lord Alfred Churchill, Count Victor Wimpffen, Sir James Crichton Brown, F.R.S., Sir James Ramsden, Sir Henry Thompson, F.R.C.S., Sir Henry Mance, C.I.E., Sir Charles Bright, Sir Samuel Canning, Sir Frederick Abel, C.B., F.R.S., Sir James Linton, President R.I.; Admiral Sir Edward Inglefield, C.B., F.R.S.; Captain Sir George Nares, R.N., K.C.B., F.R.S.; Major-General E. R. Festing, R.E., F.R.S.; Major-General C. E. Webber, R.E., C.B.; Major-General J. T. Walker, F.R.S.; Colonels Stotherd, R.E., Sir Francis Bolton, Granville Puget, Harrison, C.B., R.E.; Majors R. Y. Armstrong, R.E., J. G. B. Stopford, G. E. C. Beresford, R.E.; M'Gregor R.E.; Captains H. R. Sankey, R.E., C. A. McEvoy, Douglas Galton, C.B., F.R.S., Ladds, F. R. de Wolski, R.E., H. J. Holden, R.A.; Lieutenant Anstruther, R.E.; Monsieur E. Hospitalier, Gaston Roux; Herr Hogmeister; Profs. G. G. Stokes (President R.S.), J. C. Adams, LL.D., F.R.S., G. T. Bonney, F.R.S., Vernon Harcourt, F.R.S., G. D. Liveing, F.R.S., A. S. Herschell, F.R.S., Roberts-Austen, F.R.S., W. G. Adams, F.R.S., W. E. Ayrton, F.R.S., John Perry, F.R.S., G. C. Foster, F.R.S., A. W. Reinold, F.R.S., J. S. Fleming, M.A., D.S.C., George Forbes, F.R.S.E., Silvanus P. Thompson, F.R.A.S., F. Guthrie, F.R.S., W. N. Stocken, M.A., E. Ray Lankester, LL.D., F.R.S, John Tweedy, A. J. Bernays; Drs. Hugo Müller, F.R.S. (President Chem. Soc.), Benjamin Ward Richardson, F.R.S., E. Frankland, LLD., F.R.S., John Rae, F.R.S, J. H. Gladstone, F.R.S., J. Hopkinson, F.R.S., R. Quain, F.R.S, H. J. P. Sprengel, F.R.S., M. J. Jackson, Meymott Tidy; Messrs. J. M. Swan, W. Crookes, F.R.S., Latimer Clark, Willoughby Smith, C. E. Spagnoletti, W. H. Preece, F.R.S.; E. Greaves, W. T. Ansell, R. E. Crompton, Alexander Siemens, A. Stroh, Lant Carpenter, Gisbert Kapp, John Munro, C. H. B. Patey, J. Farquharson, E. Cowper, Conrad Cooke, C. H. W. Biggs, H. R. Kempe, S. M. McGowen, H. G. Erichsen, J. Wimshurst, Trueman Wood, C. W. Vincent, P. W. Willans, R. von F. Treuenfeld, F. Despointes, D. FitzGerald, H. Clifford, and Daniel Adamson.

TELEPHONIC STATISTICS.—The following is a continuation from our last issue of M. Rothen's telephonic statistics:—

Inter-Urban Communication.

Germany

Berlin–Magdeburg (110).	Hamburg–Bremerhaven.
Berlin–Lubec.	Francfort-s./M.-Mayence.
Berlin–Potsdam (17½).	Hamburg–Lübeck (42).
Berlin–Ludwigsfelde (25).	Brême–Bremerhaven (43).
Berlin–Charlottenburg.	Cologne–Deutz.
Crefeld–Bonn (16).	Barmen–Elberfeld.
Crefeld–Lobberich (16).	Hamburg–Altona.
Düsseldorf–Crefeld–München-Gladbach.	Cologne–Bonn (16).
	Mannheim–Heidelberg (14).
Elberfeld-Barmen-Langenberg.	Dresden–Pirna (12½).
Neuss–Cologne–Bonn.	Mulhouse–Thann (13).
Francfort-s./M.-Mannheim(53).	Mulhouse–Guebwiller (14).

The total length of the inter-town wires already amounts to 1,378 miles.

Sweden.

Stockholm-Rotebro-Upsala-Södertelji-Moulbo-Trosa-Dalarö-Vaxholm.

The gradient of these distances is 50cm.

Switzerland.

1st Group.	4th Group.
Berne-Bienne (19).	St-Gall-Amrisweil (11½).
Berne-Thoune (18½).	St-Gall-Arbon (8).
Berne-Muri (3).	St-Gall-Hérisau (6).
2nd Group.	St-Gall-Rorschach (7½).
Chaux-de-Fonds-Gernier (8½).	St-Gall-Speicher (3).
Gernier-Neuchâtel (8½).	St-Gall-Teufen (2¼).
Neuchâtel-St-Blaise (3).	5th Group.
Chaux-de-Fonds-Locle (1).	Zurich-Adliswyl (2½).
Chaux-de-Fonds-St-Imier (12).	Zurich-Affoltern (11).
3rd Group.	Affoltern-Lucerne (19).
Geneva-Bellevue (4).	Zurich-Baden (14½).
*Geneva-Lausanne (38).	Zurich-Horgen (9).
*Geneva-Nyon (14).	Horgen-Richtersweil (4½).
Geneva-Vandœuvres (3).	Zurich-Thalweil (6¼).
*Lausanne-Morges (8½).	Thalweil-Wädensweil (7).
*Morges-Nyon (15).	Zurich-Uster (11).
Lausanne-Vevey (11).	Uster-Wetzikon (4½).
Vevey-Montreux (4).	Zurich-Winterthur (12½).
Montreux-Aigle (8½).	Winterthur-Schaffhousen (16½
Aigle-Bex (6).	*Zurich-Stäfa (14½).
	Bâle-Liestal (11).

All the exchanges of each group can converse with one another. Except between Geneva and Lausanne and between St. Gall and Hérisau, where two wires are available for telephony, there is only one wire.

The communications marked with an asterisk are established by means of the Van Rysselberghe system.

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ALTERNATING AND INDUCED ELECTROMOTIVE FORCES.—I.

BY W. H. SNELL.

The first mathematical investigation on the subject of alternating and induced electromotive forces was, I think, given by Clerk Maxwell in the year 1865 (see *Phil. Trans.* for that year, p. 469). Since that date Mascart and Joubert have treated the question at length in the *Journal de Physique*, and more recently all electricians will remember that both Dr. Hopkinson and Mr. T. Blakesley have added largely to our knowledge of the subject.

So far, however, neither these writers, nor any others with whom I have made acquaintance, have shown any merciful consideration for that numerous and not wholly undeserving class of individuals whose mathematical attainments are of limited extent. There are undoubtedly many electricians who have frequently to deal with alternating currents to whom this important series of investigations remains a sealed book, or who at the best have had to content themselves with getting some idea of the general character of the results. With the advent of secondary generators these questions have become of more immediate importance, and it therefore seems to be desirable that the subject should be presented in as simple a form as its nature will permit. The writer will endeavour to show that it is possible to make considerable progress in the treatment of these problems without resorting to any abstruse mathematics; and, at the same time, it will be his endeavour to keep well in view of the physical as well as the merely mathematical reasons for the results which are obtained.

It will, however, be absolutely necessary that we should wander far afield from the primitive simplicity of the law of Ohm. It is really a remarkable fact that so long as we are dealing with electromotive forces, continuous in direction and constant in value, then no matter how numerous these may be, or how complex the circuit in which they operate, the law of Ohm, together with the corollaries deduced therefrom by Kirchoff, will suffice to determine the electrical conditions in every part of the conducting circuit. But whenever the electromotive force undergoes continual fluctuations, either in numerical value or in direction, the case immediately becomes widely different. Even in the most simple circuit we have now to consider not merely the three terms whose relations were formulated by Ohm, but we must also know the value of the coefficient of self-induction, the periodic time of the alternations, and the shape of the curve which represents the rise and fall of the electromotive force. Furthermore, if there should be any independent conducting circuits in the immediate neighbourhood, we have, in addition, to consider the coefficients of mutual induction with those circuits, and the reaction of their currents upon the current in the primary.

It seems not unlikely that some additional difficulty has been thrown in the way of students who approach this subject for the first time, by certain statements which either expressly assert or else seem distinctly to imply that the law of Ohm no longer holds good at all in the case of alternating currents. For instance, we are told that "the phase of the current lags behind the phase of the electromotive force," or in other words that the current is not at a maximum at the same moment at which the electromotive force is a maximum. Now, if so stated, this is clearly inconsistent with the law which we have been taught to consider in the light of the fundamental principle of dynamic electricity. Nevertheless, it need hardly be said that the statement is perfectly true in the sense in which it is intended by the writers who make use of it. But the electromotive force referred to is not the actual total electromotive force to which the current in the circuit is really due, but only one component part of that total. The statement, in fact, applies solely to the "impressed" electromotive force, that is to the electromotive force which is the original source of the electrical action taking place in the circuit.

Now if any circuit contain an electromotive force whose value changes from moment to moment, then that circuit must *de facto* possess at least one and possibly two or more separate and distinct electromotive forces in addition to that of the original source. It follows, of course, that the current at any moment will be equal to the algebraic sum of these electromotive forces divided by the actual resistance of the circuit. And, for reasons which we shall consider later, it also happens that the maximum value of the current at each alternation is attained somewhat later than that of the impressed electromotive force. But, upon the other hand, the rise and fall of the current is necessarily and absolutely concordant with that of the resultant or total electromotive force.

The problem of determining the periodic values of an alternating current under any given conditions is therefore resolved into that of determining the resultant E.M.F. at each moment. If we can do this, we return forthwith to the simple application of the law of Ohm; dividing the resultant E.M.F. at any moment by the actual resistance of the circuit, we obtain the current at that moment.

For the complete solution, then, of any problem whatever relating to a conducting circuit traversed by alternating currents we require only one additional fundamental principle. That principle is usually stated in the following terms:—Induced electromotive forces are at all times proportional to the rate of decrease in the total number of lines of force passing through the circuit. It may be worth while to remark at this point that the number of lines of force enclosed by a circuit can only decrease by some of the lines passing through, or "cutting," the conductor. This is because a line of force only disappears by retreating into the magnet or the conductor to which it belongs; it cannot vanish in mid air.

Let us now consider a particular case of the generation of an alternating electromotive force; and assume, in the first place, that there is no self-induction in the circuit; that is to say, suppose that none of the lines of force generated by the current in the circuit pass through the conductor at any point. It is well known that under these circumstances the lines of force belonging to the circuit surround the conductor in a series of concentric rings lying in planes perpendicular to the path of the current.

In such a circuit imagine a single loop of wire* placed in a uniform field of magnetic force, and let it be rotated about an axis which passes through the loop as a diameter, in a direction perpendicular to the direction of the lines of force. Then it is obvious that when the plane of the loop is perpendicular to the direction of the lines of force, the number of lines passing through the loop will be a maximum; when it has turned through an angle of 90° the number will be zero, and after turning through 180° the number of lines threading the loop will again be a maximum; but they now enter the loop at the opposite side.

Let the maximum number of lines which can pass through the loop be N. And let θ be the angular position of the coil, measured always in the same direction from 0° to 360°, from the position where the number of lines threaded is a maximum. Then if N_1 be the number of lines for any given valve of θ, we shall always have

$$N_1 = N \cos \theta \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

and as θ has all values from 0° to 360°, cos θ will have all values from + 1 to − 1.

Now, let E_1 be the impressed electromotive force generated in the coil at any point during the revolution. Then we know that E_1 is proportionate to the rate of decrease of the values of N_1. It therefore depends not only upon N_1, but also upon the rapidity of the rotation of the coil. Let t be some very short interval of time, then the rate at which N_1 changes during that short interval will be measured by taking the first differential coefficient of N_1 with regard to t. That is

$$E_1 = -\frac{d N_1}{d t}.$$

Substituting the value of N_1 from (1) we have

$$E_1 = -\frac{d N \cos \theta}{d t} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Now, if the time occupied in a whole revolution—that is in describing an angle of 2π radians—be T, it is obvious that the

* Of course, there would actually be a certain amount of self-induction even in a single loop.

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angle θ, which is described during the short time t will be given in radians by

$$\theta = 2\pi \frac{t}{T} \quad \ldots\ldots\ldots \quad (3)$$

Inserting this value of θ in (2) and performing the differentiation, we obtain

$$E_1 = \frac{2\pi N}{T} \sin \frac{2\pi t}{T} \quad \ldots\ldots \quad (4)$$

It will be understood that in this equation t must be given succcessively all values from 0 up to T.

The successive values of E_1 during one complete revolution may therefore be represented by the ordinates of a sinusoidal curve, and the greatest ordinate will be equal to $\frac{2\pi N}{T}$. It may be as well to note here that the rise and fall of an alternating current is not necessarily represented by a curve of sines. Theoretically the alternations might be made to take place according to some quite different law.

Let us now introduce into the circuit a coefficient of self-induction; this is usually denoted by L. And, in the first place, it must be remembered that coefficients of self (and also mutual) induction properly belong to the circuit *as a whole*, so that if the value of L be the same it is a matter of indifference whether the self-induction takes place in the armature of the dynamo or in any other part or parts of the circuit. Now, there are four separate and distinct terms belonging to self-induction which it is important to carefully distinguish. These are (1) the coefficient of self-induction; (2), the total self-induction; (3), the electromotive force of self-induction; (4), the current of self-induction. And their definitions are as follows:—(1), the coefficient of self-induction is a concrete quantity representing the numbers of its own lines of force which would be enclosed by the circuit if it were traversed by a unit current; (2), the total self-induction of a circuit at any time is measured by the product L I, where I is the current at the moment; (3), the electromotive force of self-induction depends, like other induced electromotive forces, upon the rate of change in the number of the lines of force to which is due. It must therefore be measured by

$$E_2 = -\frac{d\,L\,I}{dt} \quad \ldots\ldots\ldots \quad (5)$$

[4.] Finally, the current of self-induction is, of course, equal to E_2 divided by the total actual resistance of the circuit.

There are several points in connection with these definitions which it will be well to notice before we proceed. Strictly speaking the coefficient of self-induction depends solely upon the geometry of the circuit. It has a minimum value when the conductor takes the form of a single wide loop, but in a circuit of the same length and resistance, part of which is coiled up, the value of L increases very nearly in proportion to the square of the number of turns in the coil. But if L be taken as a function of the geometry of the circuit alone, then the *total* self-induction of the circuit will depend not only upon L and upon I, but also upon the magnetic permeability of the space adjacent to the circuit. And if this space contain iron the self-induction will be very greatly increased. Theoretically we ought, therefore, to express the total self-induction as a function of the strength of the current multiplied into the sum of two terms, of which the second would be a somewhat complex expression—it would contain a saturation term, and also the coefficient of magnetic permeability, which latter varies for every different kind of iron. In practice it is, therefore, much more simple to take L as representing the whole number of lines of force embraced by the circuit, and due immediately to the current in the circuit, whether they belong to the conductor or whether they belong to adjacent masses of iron. This convention will not require any alteration in our definition of L, but the total self-induction will now only be proportionate to L I so long as we are working at some distance from the saturation point of the iron. Practically, in induction circuits it may be safely assumed that this will be the most general case. Another point that may be noted in connection with L, is that this number bears no necessary relation whatever to the number of lines in the magnetic field in which the current is generated. This will be sufficiently obvious if we consider that L may be increased indefinitely by continuously increasing the length of the conductor. And if its diameter be increased at the same time in such a manner as to maintain its resistance constant, then the *total* self-induction will also increase indefinitely.

Now, let E be the total or resultant E.M.F. in the circuit, so that E is equal to the sum of the values of E_1 and E_2 taken with their proper signs. That is from (4) and (5)

$$E = \frac{2\pi N}{T} \sin \frac{2\pi t}{T} - L\frac{d\,I}{d\,t} \quad \ldots\ldots \quad (6)$$

Now, in this equation we cannot directly perform the differentiation indicated in the last term, because we do not at present know the value of I nor its relation to t. But we may proceed to solve the equation by means of a series of successive approximations (without treating it as a differential equation) in the following way:—Divide both sides by R, the total resistance of the circuit, thus

$$\frac{E}{R} = I = \frac{2\pi N}{RT} \sin \frac{2\pi t}{T} - \frac{L}{R}\frac{d\,I}{d\,t} \quad \ldots \quad (7)$$

Now, as a first approximation to the value of I we may neglect the term containing L and put

$$I_1 = \frac{2\pi N}{RT} \sin \frac{2\pi t}{T} \quad \ldots\ldots \quad (8)$$

Substitute I_1 for I in the second term of (7), then as a second approximation we have

$$I_2 = \frac{2\pi N}{RT}\left(\sin\frac{2\pi t}{T} - \frac{L}{R}\frac{d}{dt}\sin\frac{2\pi t}{T}\right)$$

$$= \frac{2\pi N}{RT}\left(\sin\frac{2\pi t}{T} - \frac{L}{R}\frac{2\pi}{T}\cos\frac{2\pi t}{T}\right)$$

We may now replace I by I_2 on the right hand side of (7), and so obtain a third approximation. If we proceed in this way the following are the values of the successive approximations for the first four terms after I_1. For the sake of brevity we will put θ for $\frac{2\pi t}{T}$ as before, and we will also write a for the expression $\frac{L}{R}\frac{2\pi}{T}$.

$$I_2 = \frac{2\pi N}{RT}(\sin\theta - a\cos\theta) \quad \ldots\ldots\ldots \quad (8a).$$

$$I_3 = \frac{2\pi N}{RT}(\sin\theta - a\cos\theta - a^2\sin\theta) \quad \ldots\ldots \quad (8b).$$

$$I_4 = \frac{2\pi N}{RT}(\sin\theta - a\cos\theta - a^2\sin\theta + a^3\cos\theta) \quad \ldots \quad (8c)$$

$$I_5 = \frac{2\pi N}{RT}(\sin\theta - a\cos\theta - a^2\sin\theta + a^3\cos\theta + a^4\sin\theta) \quad (8d)$$

We have written down these four terms in full in order that the law of their formation may easily be seen by inspection, especially with regard to the signs of the successive terms.

It will now be clear that the value of I may be expressed as the sum of an infinite number of terms of this series, multiplied into the factor $\frac{2\pi N}{RT}$. But the series may be written in the form $\sin\theta(1 - a^2 + a^4 - \ldots) - \cos\theta(a - a^3 + a^5 - \ldots)$; that is, $(1 - a^2 + a^4 - \ldots)(\sin\theta - a\cos\theta)$.

And the sum to infinity of this geometrical progression is equal to $\frac{1}{1+a^2}$

So that finally

$$I = \frac{2\pi N}{RT} \cdot \frac{(\sin\theta - a\cos\theta)}{(1+a^2)} \quad \ldots\ldots \quad (9)$$

or in full

$$I = \frac{2\pi N}{RT} \cdot \frac{\left(\sin\theta - \frac{2\pi L}{RT}\cos\theta\right)}{\left\{1 + \left(\frac{2\pi L}{RT}\right)^2\right\}} \quad \ldots \quad (9a)$$

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The value of I may, however, be obtained in a more convenient form by making the following trigonometrical transformation. First let ϕ be an angle whose tangent is equal to a, that is let

$$\phi = \tan^{-1} a.$$

Then

$$\frac{\sin\theta - a\cos\theta}{\sqrt{1+a^2}} = \frac{\sin\theta - \cos\theta\tan\phi}{\sqrt{1+\tan^2\phi}}$$
$$= \sin\theta\cos\phi - \cos\theta\sin\phi$$
$$= \sin(\theta - \phi)$$

Making this substitution in (9) we get

$$I = \frac{2\pi N}{RT} \cdot \frac{\sin(\theta-\phi)}{\sqrt{1+a^2}}$$

or

$$I = \frac{2\pi N}{T} \cdot \frac{\sin(\theta-\phi)}{\sqrt{\left(\frac{2\pi L}{T}\right)^2 + R^2}} \quad . \quad (10)$$

Now, if there were no self-induction in the circuit I would have the value I_1 in (8). It, therefore, appears that self-induction has the effect of reducing the mean value of the current in the proportion

$$\frac{R}{\sqrt{\left(\frac{2\pi L}{T}\right)^2 + R^2}}$$

and at the same time the rise and fall of the current is evidently retarded. The impressed E.M.F. will be at a maximum when $\theta = 90°$; that is, when the plane of the coil is parallel with the lines of force of the magnetic field, and the number of lines passing through the coil is for the moment zero. But the resultant current attains its maximum at the moment when $\sin(\theta - \phi) = 1$, that is when $(\theta - \phi) = 90°$. In the next paper we shall give a diagram from which the physical cause of the retardation of the current may very readily be inferred. All that we have done at present is to ascertain its existence as a mathematical fact. In the meantime, we may note that the angle ϕ remains constant (through all the changes of θ) so long as the resistance of the circuit, its coefficient of self-induction, and the speed of rotation are unchanged.

PRACTICAL ELECTRICITY FOR AMATEURS.—IV.* Electric Bells and Indicators.—*(Continued.)*

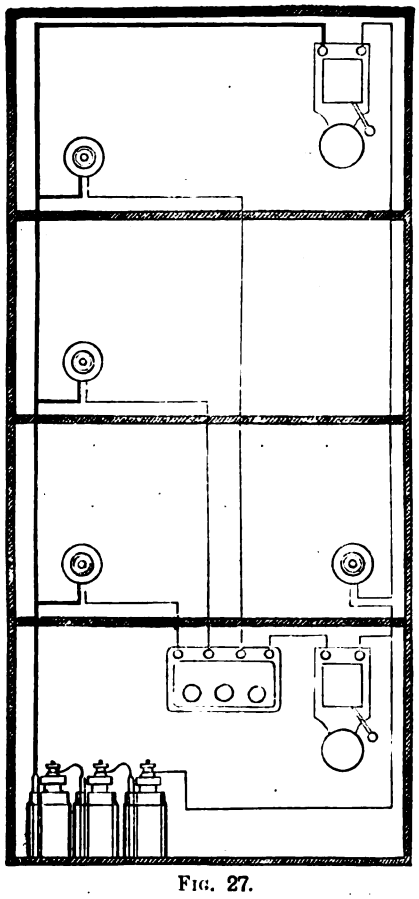

Fig. 27.

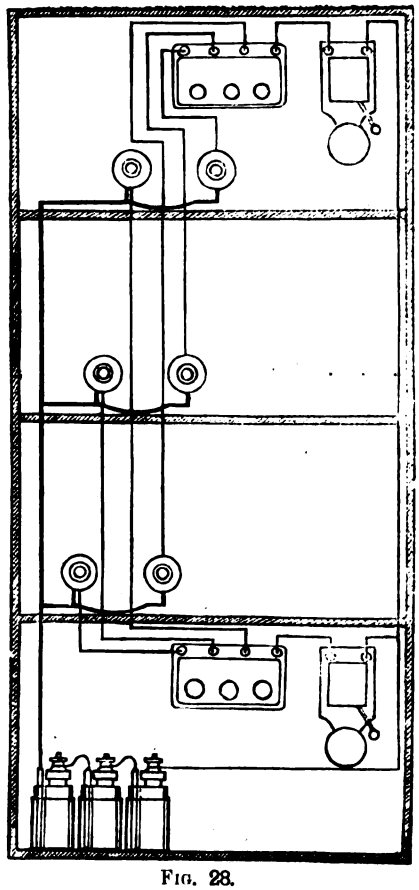

Fig. 28.

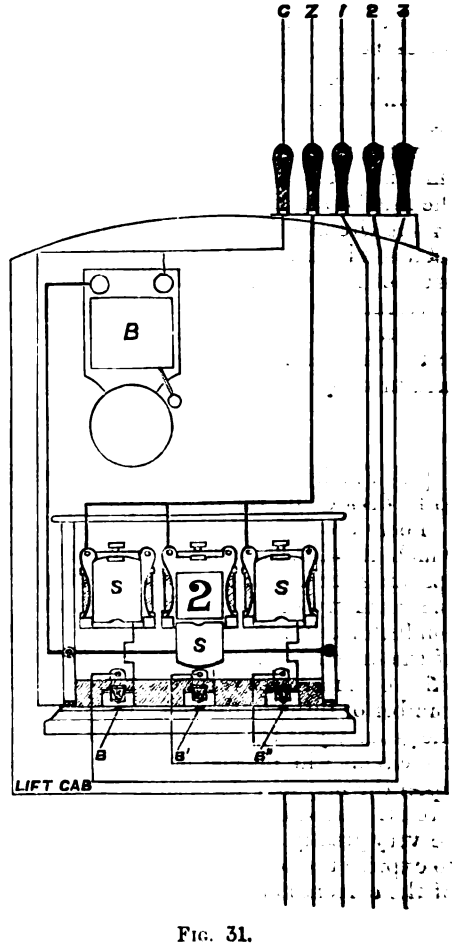

Fig. 31.

Fig. 27 shows the most simple arrangement of electric bells and indicators, having three rooms to ring downstairs, and one push in hall to ring at top of house.

Fig. 28 shows arrangement having two pushes in each room, one to ring upstairs and the other downstairs.

Fig. 29 shows an arrangement such as would be used in a hotel or large establishment. The indicator placed on each floor shows the particular room, the indicator on ground floor merely indicates the floor. This arrangement saves carrying all the wires to the ground floor, and is more convenient in many respects.

Figs. 30, 31, and 32 show an arrangement of electric bells and indicators applied to a lift enabling any person from any floor to ring a bell and indicate the floor in the lift cab, and to receive a ring in reply, and this can be done in whatever position the lift cab may be in. Fig. 30 shows the bare wires, C, Z, 1, 2, 3, running from top to bottom of lift well, and kept tight by weights placed at the bottom, also the connections on each landing. The connections with the cab are maintained by the rubbing contacts C, C', and are shown in Fig. 31, which also shows the connections in cab.

Fig. 32 shows how the contacts C, C', &c., act against the bare wires before named.

* For Article III. see *The Electrician* for June 11, 1886.

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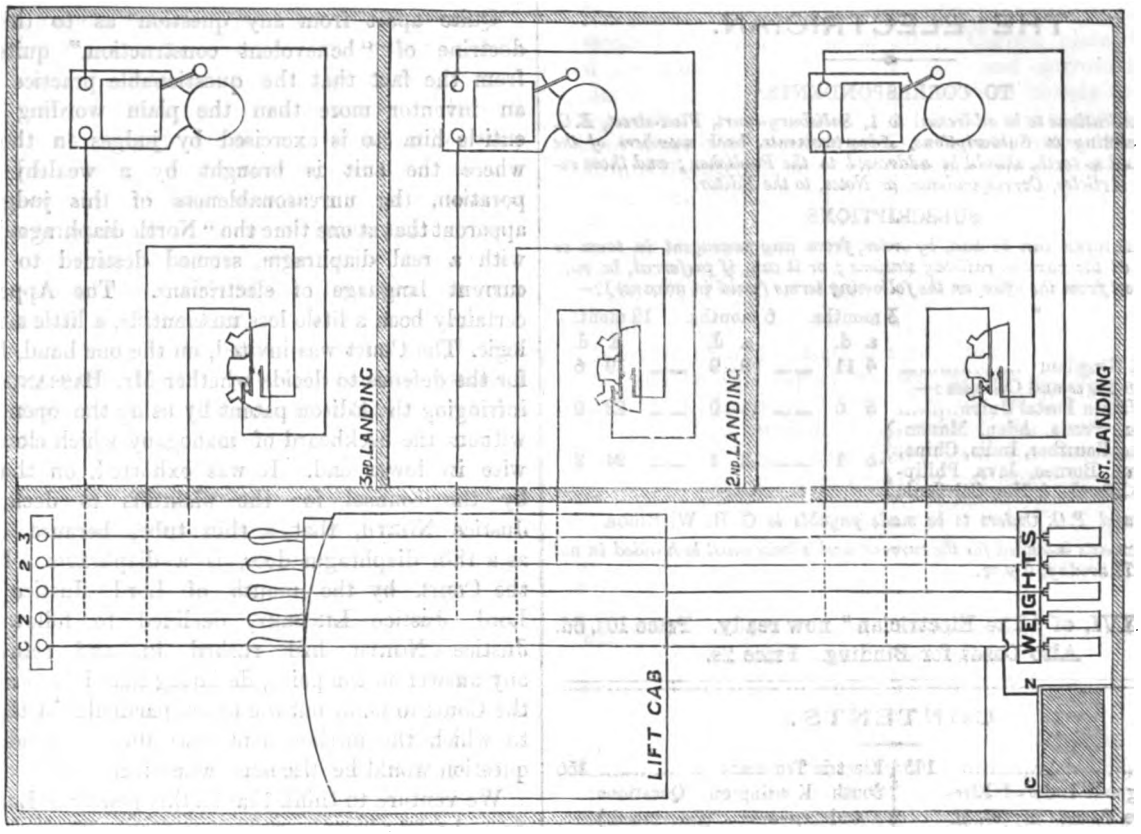

FIG. 30.

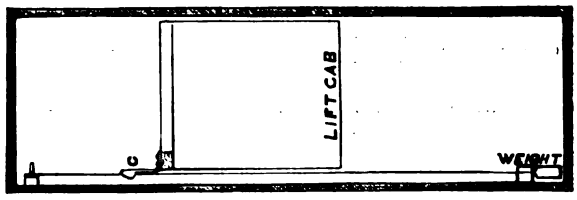

FIG. 32.

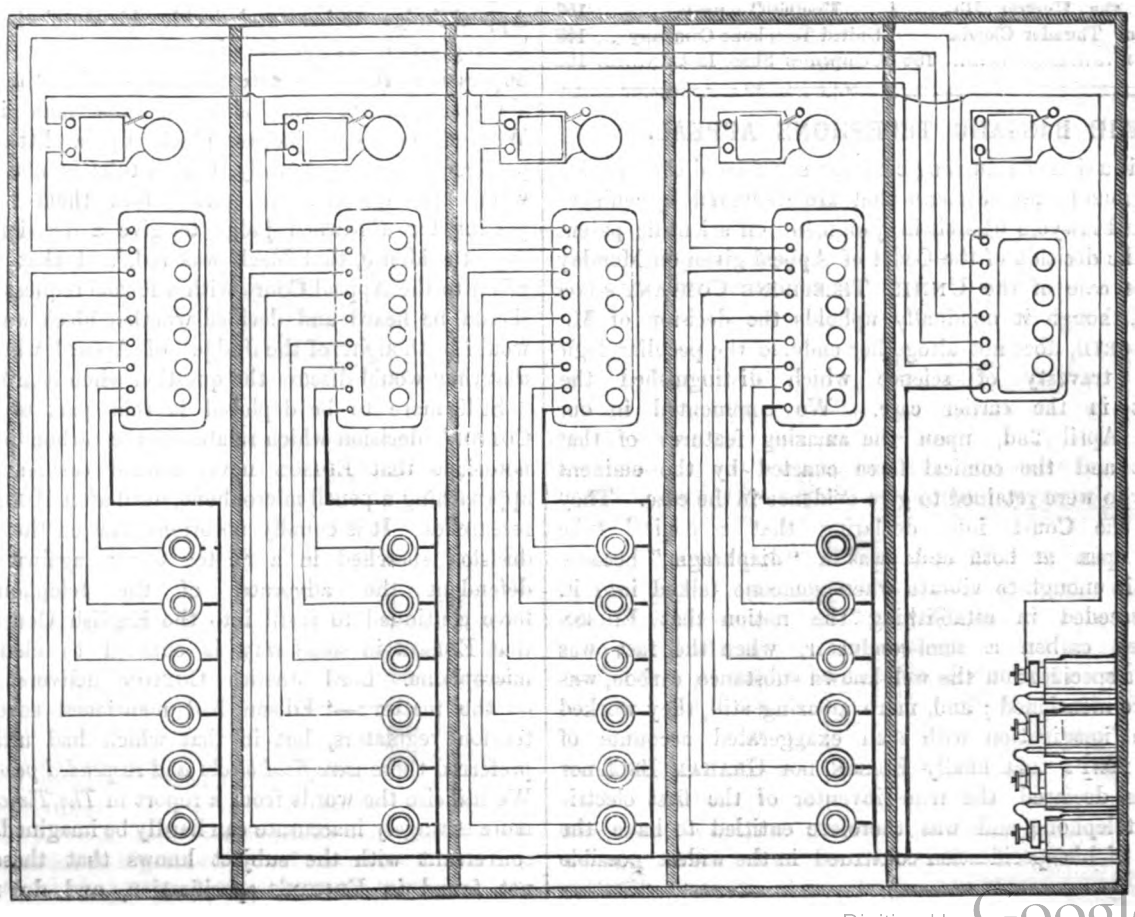

FIG. 28.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

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THE BASSANO TELEPHONE APPEAL.

There is a sign of returning common sense amid the amusing and ludicrous pronouncements that are delivered by eminent and learned lawyers who sit in judgment on scientific patent cases. The decision of the Court of Appeal given on Monday last in the case of the UNITED TELEPHONE COMPANY *versus* BASSANO, though it nominally upholds the decision of Mr. Justice NORTH, does not altogether endorse the peculiar logic and the travesty of science which distinguished the judgment in the earlier case. We commented in our issue of April 2nd, upon the amazing features of that judgment and the comical farce enacted by the eminent experts who were retained to give evidence in the case. They deluded the Court into declaring that a conical tube of wood open at both ends was a "diaphragm," because it was thin enough to vibrate when someone talked into it. They succeeded in establishing the notion that EDISON had called carbon a semi-conductor, when the fact was that in his specification the well-known substance, carbon, was never once mentioned; and, more amazing still, they worked upon the imagination with such exaggerated accounts of EDISON'S merits that finally EDISON, not GRAHAM BELL nor REIS, was declared the true inventor of the first electric speaking telephone, and was therefore entitled to have the language of his specification construed in the widest possible sense.

Quite apart from any question as to this mischievous doctrine of "benevolent construction," quite apart, too, from the fact that the questionable practice of giving to an inventor more than the plain wording of his claims entitle him to is exercised by judges in those cases only where the suit is brought by a wealthy firm or corporation, the unreasonableness of this judgment was so apparent that at one time the "North diaphragm," as contrasted with a real diaphragm, seemed destined to pass into the current language of electricians. The Appeal Court has certainly been a little less unscientific, a little more strict in its logic. The Court was invited, on the one hand, by the counsel for the defence to decide whether Mr. BASSANO would still be infringing the Edison patent by using the open wooden tube without the backboard of mahogany which closed diaphragm-wise its lower end. It was exhorted, on the other hand, by the counsel for the plaintiffs to declare, with Mr. Justice NORTH, that a thin tube, because it can vibrate as a thin diaphragm does, is a diaphragm. In the sequel the Court, by the mouth of Lord Justice COTTON and Lord Justice LINDLEY, declined to follow where Mr. Justice NORTH had rushed in, and refused to make any answer on the point, declaring that it was not the duty of the Court to point out the exact particular of the construction to which the infringement was due, and added that the question would be discussed when it arose.

We venture to think that on this point the Lords Justices of Appeal might have been more explicit. The point had actually arisen in the Court below; it had been treated as a distinct issue by Mr. Justice NORTH. Some of the actual instruments brought into court as infringements possessed no backboard. A grievous injustice has, as it seems to us, been inflicted on Mr. BASSANO by the refusal of the Court to entertain and decide this simple issue. It is perfectly plain to every unbiased mind that when EDISON said diaphragm he meant diaphragm, and did not mean tube. The refusal of the Appeal Judges to hear and decide this simple issue is much to be regretted, as it is giving countenance to a growing impression that in cases of this kind the Court must always lean to the side of the man in possession. Why cannot our judges pluck up a little more independence, and say plainly that a tube is not a diaphragm when the question is put before them? Suppose it possible for a learned judge to give a decision, based upon expert evidence, that black was red, and that the case were taken to the Appeal Court with a formal request that the issue should be heard and decided whether black was red. What would be thought of the Judges of Appeal who should reply that they would discuss the question when it arose?

Still more to be deplored is that part of Lord Justice COTTON'S decision which relates to the carbon question. It is notorious that EDISON never named carbon, or anything approaching a pencil microphone, until after HUGHES'S classical researches. It is equally notorious that on the strength of a decision snatched in a Scotch Court against a bankrupt defendant the advocates of the telephone monopoly have continued to instil into the English Courts the notion that EDISON in some way is entitled to claim HUGHES'S microphone. Lord Justice COTTON delivers himself thus on the matter:—"Edison had mentioned several sorts of tension regulators, but in that which had ultimately been preferred there *were fixed blocks and suspended pencils of carbon.*" We italicise the words from a report in *The Times*. Anything more strangely inaccurate can hardly be imagined. Every one conversant with the subject knows that these words are not found in EDISON'S specification, and do not describe

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anything to be found therein, but describe HUGHES'S microphone. The judge goes on to say: "Substantially *the same thing* was used in the defendants' instrument, *though the carbons were fixed to the base of the speaking tube* instead of being situated, as in EDISON'S instrument, on the other side of the diaphragm. *In his Lordship's opinion the defendants' instrument was an infringement of Edison's patent.*" It is difficult to conceive a more unscientific mode of argument. First import into EDISON'S specification something that was not there to begin with, but which was the subsequent invention of Hughes; then discover that the defendants' instrument is so much like it as to be practically the same; then declare it to be an infringement! This is virtually what the united wisdom of bench, bar, and professional experts has succeeded in doing.

CORRESPONDENCE.

THE THOMSON-HOUSTON SYSTEM.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: We notice in to-day's paper that you mention the City of Hernosand, Sweden, as being the first city in Europe where electricity has entirely superseded gas for public lighting, and as you have mentioned the fact, we think it right that you should also name the system adopted, which is the Thomson-Houston. This installation was the first result of the gold medal awarded to us at the Inventions Exhibition last year, and the plant has been running with the utmost satisfaction to everybody concerned since November last.—Yours, &c.

LAING, WHARTON, AND DOWN.

London, E.C., June 26th, 1886.

THE UPWARD PRIMARY BATTERY.

For a long time past great efforts have been made to induce the general public to believe in primary batteries for electric lighting purposes. The most glowing accounts as to cost, cleanliness, non-supervision, and other properties, appealing to the public have been freely circulated. It needs a strong mind and most careful analysis to cast aside the glamour of

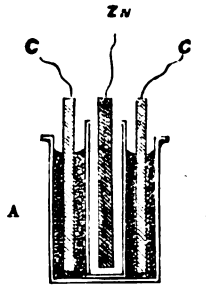

FIG. 1.

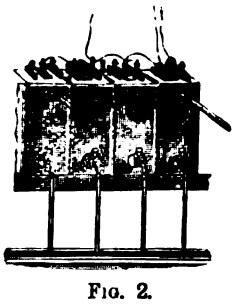

FIG. 2.

the descriptions given by patentees and manufacturers, and to show that so far, there is in existence no single battery that is anything but a luxury for electric lighting purposes. The public is imposed upon by half truths. Primary batteries are not such simple things as many imagine. It is needless, however, to enter into a long discussion upon these points at present. Let us accept for the moment that such apparatus is intended for those only who can afford to pay for luxuries, and our way is made clear. Under these conditions the battery invented by Mr. Upward, and made by Messrs. Woodhouse and Rawson, is a success. Viewed scientifically it possesses many interesting features. It is at once a gas battery and a single fluid battery. Our readers will better understand the battery from the section in Fig. 1, and the cells as in use in Fig. 2. In Fig. 2 the vertical glass tubes are the drainage tubes.

A is a glazed earthen vessel containing a porous jar. Inside the porous jar is placed a slab of zinc. Carbon plates CC are placed on each side the porous jar, and surrounded by granular crushed carbon packed and pressed closely together. The top of the carbon compartment of the cell is hermetically sealed by a material of the nature of marine glue—hence, no gas let into the carbon can escape except through the porous jar. The zinc plate in this jar is surrounded by a solution of chloride of zinc. When the cell is required for use gaseous chlorine enters, or rather is drawn into, the cell by a very interesting arrangement. A lead pipe goes from the top of one cell to the bottom of the next, and the gas passes from cell to cell through these pipes. Messrs. Woodhouse and Rawson have favoured us with a copy of Prof. Lodge's report upon this battery, and to this report we are largely indebted in this article. Dr. Lodge says, "The elements of the battery are zinc immersed in a solution of chloride of zinc contained in a porous vessel, on the one hand; and crushed carbon immersed in gaseous chlorine and kept moist by the deliquescent action of the zinc-chloride which oozes through the porous pot into the outer vessel, on the other. The outer vessel is allowed constantly to drain so as to never contain any loose liquid; it is only intended to contain as much as will keep the carbon properly moist. When the circuit is closed zinc dissolves and chlorine is taken up in precisely equivalent proportions, and when the circuit is open no chemical action occurs, the zinc being entirely unattacked, and all chemical action being in abeyance except when a current passes. The solution in the inner vessel tends to become stronger as the battery is worked, the chloride of zinc needed being generated by the battery's own action; so if loss of fluid be made up by addition of plain water it is possible to keep the solution at a reasonably constant strength. The deliquescent property of zinc-chloride prevents any difficulty with crystallisation and creeping. If the battery is in regular work it should give little or no trouble, and even if it stand idle for long the only change is that the liquid in the porous cells either falls in level or else becomes more dilute. . . . No mixing of solutions can occur, as there is only the one liquid and there is no electrical waste on standing, for as soon as the supply of chlorine is exhausted the battery stops working. The E.M.F. of the battery is from 2 to 2·1 volts, and it is extremely constant so long as a free supply of chlorine is maintained."

It will be seen that the active ingredient is chlorine gas. This gas is by no means a harmless gas to handle, and precautions have to be taken for its manufacture and storage. In the experimental installation at the works of Messrs. Woodhouse and Rawson it is obtained from common salt. A glazed earthenware jar, or retort, of the size required, is placed in a sand bath. The retort is charged with the materials used, and a gentle heat applied. The gas is given off and stored in an ingenious gasometer, consisting of glazed drain pipes placed on end and hermetically sealed at the junctions. From tier to tier of pipes is a leaden tube carrying a glass bulb. This bulb being placed near the top of the tier enables the workmen to see when the gasometer is full. The gas can be drawn from the store as required. "From the holder the gas passes through lead pipes to the series of cells into which it is drawn by their own action in a constant stream while they are working. At intervals, however, a supply is needed for a short time greater than what the mere absorbing power of the carbon can provide. Whenever this happens a very beautiful automatic arrangement turns on a small water aspirator, and sucks in the necessary extra gas. This part of the apparatus may be taken as almost perfect or likely at once to become so. The obvious question of smell suggests itself, but it will be found that the battery and the gas holder are so well sealed up that from them there is practically no smell at all. Any slight excess of unconsumed chlorine which the water aspirator may suck through (and it is very slight, for the aspirator only acts for a minute or so at a time, and rests for an hour or more) is at once carried down into the drains, where it must do the reverse of harm. The internal resistance of a cell as now constructed is rather high, being about a quarter or a fifth of an ohm. This is a distinct disadvantage, as it renders the battery non-self-regu-

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lating when working by itself, but the patentees have evaded this objection by combining with it a secondary or storage battery of about half the number of cells; these constitute the real source whence the external circuit is worked, and, of course, they are perfectly self-regulating, so that whether one lamp or thirty are lighted the change need make no difference to the potentials of the terminals, and therefore to the brilliancy of the lights. The function of the primary battery is thus simply to keep the storage battery always full. . . . The primary and secondary batteries are never in practice disconnected. So soon as the secondary is full the primary slackens and chlorine is drawn into it less quickly. Directly the secondary is drawn upon, the primary at once begins to make up the deficiency and its activity varies with the demand made upon it. No back current can ever be formed, and the constant filling and occasional overfilling of the accumulators is exactly the condition under which they are known to work best and last longest. Accumulators so charged are, in fact, in quite the most favourable circumstances, and may be expected to give no trouble. The virtual power of the primary is of course by this arrangement enhanced, since it may take all day to replenish the loss of a few hardworking hours, so that a battery of given dimensions and prime cost is enabled to run a larger number of lamps than if it were only working during lighting hours. Moreover, the use of accumulators enables the battery to work often at more moderate activity instead of always straining at its maximum output.

"When the battery is properly and finally set up it may be trusted to work quite regularly and without attention day and night so long as the chlorine is made when required, and so long as fresh water is added both to the primary and the secondary cells. This last operation, the addition of water, is a very simple one, and it may perhaps be made automatic, in which case there will be nothing to see to but the manufacture of chlorine whenever the store in the gasholder gets low." Dr. Lodge says that "the main first cost of an installation consists of the cells, of which two primary and one secondary are needed, for every couple of volts demanded in the circuit. The working cost is made up of zinc, chlorine, and attendance. The last item may be treated as negligible in any house where a boy or man is already kept. 1·2 gramme of zinc are dissolved in each cell per ampere-hour. When the battery is working at full power this means 1,200 grammes of zinc per 1,000 watt hours; when it is gently maintaining the charge of a full accumulator it means little more than 900 grammes of zinc per 1,000 watt hours. But, inasmuch as something is lost in storage we can hardly reckon less than 1½ kilogrammes or 3·3lb. of zinc consumed altogether per 1,000 watt hours actually used."

With regard to the cost of chlorine, it must differ according to the method by which it is prepared, and also according to the quantities required. Dr. Lodge agrees that certain claims made by the patentees as to the advantages of this battery over others in the market are not claimed unjustly. We are entirely in accord with him on this point. They are—

"1. So long as the battery is in regular work, and provided the porosity of the cells has been properly adjusted to begin with, nothing but plain water has to be added occasionally to the battery and no emptying and filling of cells with acid or corrosive liquid of any kind is required.

"2. The plates are never touched or moved from the batteries from the time the zincs are put in till they are consumed, which may be about once a month of usual electric lighting work.

"3. When the battery is at work the zincs are consumed uniformly down to a thin wafer, thus using the whole plate without waste, and enabling all the plates to be renewed on the same day. This equable wear of the plates is an important point, and it is not a matter of accident. It is due to the fact that the same current passes through every cell and to the absence of local or irregular action.

"4. The carbonplates are once for all sealed into their places and never removed.

"5. There is no creeping, and consequently the terminals do not corrode.

"6. There is no polarisation, and the E.M.F. is constant.

"7. There is no local action, and when idle the zincs are not at all corroded. They may stand in the solution unaffected for any length of time. The consumption of materials is simply proportional to the current drawn off, and ceases altogether when the circuit is open.

"8. No removing of the plates for amalgamation is necessary, nor is there any expense or trouble with mercury, ordinary commercial zinc cast in plates without any amalgamation being used.

"9. No washing of porous pots or other parts of the battery is required.

"10. The battery is mainly self-acting; all that is wanted is to supply the cells occasionally with water, and to make the chlorine, a process which by special design of generator is rendered simple.

"11. The light is available at any time of day or night, and it is perfectly steady.

"12. The high E.M.F. of 2·1 volts is that due to the direct action of chlorine upon zinc, and no third substance or 'depolariser' is used at all.

"13. The battery is of a permanent nature. The whole primary battery apparatus may be left standing for months without depreciation, and can be started by filling up the pots and admitting the gas.

"14. There is no smell, dirt, or fume from the cells or from the gasholder.

"15. The arrangements for storing the chlorine, and for its automatic supply to the cells as required, are exceedingly satisfactory and ingenious."

We shall have to return to this subject.

ELECTRICAL THEORIES.

BY PROF. J. J. THOMSON, M.A., F.R.S.

(Continued from page 139.)

The equations we have arrived at for the dielectric currents seem inconsistent with Helmholtz's definition of them; for since

$$x = \epsilon X,$$

with similar equations for y and z, and since in a medium at rest

$$X = -\frac{dU}{dt} - \frac{d\phi}{dx}, \quad Y = -\frac{dV}{dt} - \frac{d\phi}{dy}, \quad Z = -\frac{dW}{dt} - \frac{d\phi}{dz},$$

where U, V, W are the components of the vector potential. If we consider a surface separating two portions of the same dielectric and coated with electricity whose surface-density is σ, we have, since U, V, W are not discontinuous on crossing the surface,

$$l(\dot{x}_1 - \dot{x}_2) + m(\dot{y}_1 - \dot{y}_2) + n(\dot{z}_1 - \dot{z}_2) = -\epsilon \frac{d}{dt}\left[l\frac{d\phi}{dx} + m\frac{d\phi}{dy} + n\frac{d\phi}{dz}\right]_1^2,$$

where $\left[l\frac{d\phi}{dx} + m\frac{d\phi}{dy} + n\frac{d\phi}{dz}\right]_1^2$ denotes the difference between the values of $l\frac{d\phi}{dx} + m\frac{d\phi}{dy} + n\frac{d\phi}{dz}$ on the two sides of the surface.

But $$\left[l\frac{d\phi}{dx} + m\frac{d\phi}{dy} + n\frac{d\phi}{dz}\right]_1^2 = -\frac{1}{1+4\pi\epsilon}\sigma,$$

so that $$l(\dot{x}_1 - \dot{x}_2) + m(\dot{y}_1 - \dot{y}_2) + n(\dot{z}_1 - \dot{z}_2) = \frac{\epsilon}{1+4\pi\epsilon}\frac{d}{dt}\sigma,$$

and so cannot vanish if the surface-density of the electricity changes; thus Helmholtz's equation seems to be inconsistent with the principle that the change in the quantity of free electricity is caused by conduction currents. In the case above considered, Maxwell's equations lead to no difficulty; it does not follow, however, that Maxwell's assumption that the total current behaves like the flow of an incompressible fluid is absolutely necessary. We shall consider later on the differences which the abandonment of this assumption will make in the theory.

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We shall now go on to consider Helmholtz's equations and compare them with the corresponding ones in Maxwell's theory.

The quantities U, V, W are given by equation of the form

$$U = \tfrac{1}{2}(1-k)\frac{d\psi}{dx} + \iiint \frac{u}{r}\,d\xi\,d\eta\,d\zeta,$$

where k is the constant which we mentioned before as occurring in Helmholtz's theory, and

$$\psi = -\frac{1}{2\pi}\iiint \frac{d\phi}{dt}\frac{1}{r}\,d\xi\,d\eta\,d\zeta,$$

where ϕ is the electrostatic potential; it follows from these equations that

$$\frac{dU}{dx} + \frac{dV}{dy} + \frac{dW}{dz} = -k\frac{d\phi}{dt}.$$

The corresponding equation in Maxwell's theory is

$$\frac{dU}{dx} + \frac{dV}{dy} + \frac{dW}{dz} = 0,$$

so that these equations coincide if $k=0$. On Helmholtz's theory, this quantity would also vanish, whatever be the value of k, if the *total* current behaved like the flow of an incompressible fluid.

If α, β, γ are the components of the magnetic force, then, on Helmholtz's theory,

$$\frac{d\gamma}{dy} - \frac{d\beta}{dz} = A\left\{\frac{d^2\phi}{dt\,dx} - 4\pi u\right\},$$
$$\frac{d\alpha}{dz} - \frac{d\gamma}{dx} = A\left\{\frac{d^2\phi}{dt\,dy} - 4\pi v\right\},$$
$$\frac{d\beta}{dx} - \frac{d\alpha}{dy} = A\left\{\frac{d^2\phi}{dt\,dz} - 4\pi w\right\},$$

where A is a quantity depending on the unit of current adopted, and is such that the force between two parallel elements of currents at right angles to the line joining them is

$$\tfrac{1}{2}\frac{A^2}{r^2}\,ij\,ds\,ds',$$

where r is the distance between the elements, ij the current through them, and ds ds' their lengths; the corresponding equations on Maxwell's theory are

$$\frac{d\gamma}{dy} - \frac{d\beta}{dz} = 4\pi u,$$

with similar equations for v and w.

If λ, μ, ν are the intensities of magnetisation, θ the coefficient of induced magnetisation, the equations satisfied by the components of the dielectric and magnetic polarisation are of the type

$$\nabla^2 x = \frac{4\pi\epsilon(1+4\pi\theta)}{(1+4\pi\epsilon_0)(1+4\pi\theta_0)}A^2\frac{d^2x}{dt^2} + \left\{1 - \frac{(1+4\pi\theta)(1+4\pi\epsilon)}{k}\right\}\frac{d}{dx}\left\{\frac{dx}{dx} + \frac{dy}{dy} + \frac{dz}{dz}\right\},$$

$$\nabla^2\lambda = \frac{4\pi\epsilon(1+4\pi\theta)}{(1+4\pi\epsilon_0)(1+4\pi\theta_0)}A^2\frac{d^2\lambda}{dt^2},$$

where ϵ_0 and θ_0 are the values of ϵ and θ for air.

These equations show that the dielectric and magnetic polarisations are propagated by waves. For the dielectric polarisation longitudinal waves are propagated with the velocity

$$\frac{1}{A}\left\{\frac{(1+4\pi\epsilon)}{4\pi\epsilon k}\frac{(1+4\pi\epsilon_0)}{(1+4\pi\theta_0)}\right\}^{\frac{1}{2}}.$$

Transverse waves are propagated with the velocity

$$\frac{1}{A}\sqrt{\frac{(1+4\pi\epsilon_0)}{4\pi\epsilon}\frac{(1+4\pi\theta_0)}{(1+4\pi\theta)}}.$$

Longitudinal waves of magnetic disturbances are propagated with an infinite velocity, and transverse ones with the same velocity as the transverse waves of dielectric polarisation. The electrostatic potential is propagated with the velocity $1/A\sqrt{k}$. In Maxwell's theory the corresponding equations are

$$\nabla^2 x = \mu K\frac{d^2x}{dt^2}, \qquad \nabla^2\lambda = \mu K\frac{d^2\lambda}{dt^2},$$

where μ is the magnetic permeability and K the specific inductive capacity, so that for both dielectric and magnetic polarisation the velocity of the longitudinal wave is infinite, while the velocity of the transverse wave is $1/\sqrt{\mu K}$. The velocity of propagation of the electrostatic potential is infinite. If in Helmholtz's theory we put $k=0$, $\theta_0=0$, $\epsilon/\epsilon_0 = K$, while both ϵ and ϵ_0 are infinite, we see that the results of his theory will in this respect agree with Maxwell's.

Though in Maxwell's theory the velocity of propagation of the electrostatic potential is infinite, and in Helmholtz's theory $1/A\sqrt{k}$, the electromotive force at a point, and consequently the dielectric polarisation, does not travel with an infinite velocity in Maxwell's theory, or with the velocity $1/A\sqrt{k}$ in Helmholtz's. We can see the reason of this more easily from Maxwell's theory, as the equations are simpler.

Using the notation of that theory, viz., f, g, h, for the components of the electric displacement, F, G, H for the components of the vector potential, and ϕ for the electrostatic potential, then in a dielectric the equations are

$$\frac{4\pi}{K}f = -\frac{dF}{dt} - \frac{d\phi}{dx}$$
$$\frac{4\pi}{K}\frac{df}{dt} = -\frac{d^2F}{dt^2} - \frac{d^2\phi}{dx\,dt};$$

but since $$4\pi\mu\frac{df}{dt} = -\nabla^2 F,$$

we see that $$\frac{1}{\mu K}\nabla^2 F = \frac{d^2F}{dt^2} + \frac{d^2\phi}{dx\,dt}.$$

Now, since $\nabla^2\phi = 0$, a particular solution of this differential equation will be

$$\frac{dF}{dt} + \frac{d\phi}{dx} = 0,$$

while the general solution will be the sum of this solution and the general solution of

$$\frac{1}{\mu K}\nabla^2 F = \frac{d^2F}{dt^2}.$$

(To be continued.)

WEST AFRICAN CABLES.

We learn that on July 1st the India Rubber, Gutta Percha, and Telegraph Works Company handed over to the African Direct Telegraph Company the cables between St. Vincent and S. Thiago, and between the latter place and Bathurst; these sections having been laid by the Silvertown Company, whose ships, the "Dacia" and the "Buccaneer," have, as previously announced, also completed the cables between Senegal and Bathurst, and Bathurst and Bolama.

The West African Telegraph Company has received information that their cable has been completed between Konakri and Sierra Leone by the Silvertown Company's ships, and as the Telegraph Construction and Maintenance Company have two ships in the same locality we may expect from day to day to hear of the completion of the African Direct Telegraph Company's cable between Bathurst and Sierra Leone, thus giving duplicate communication with Europe to the latter place. The rate agreed to by the West African Telegraph Company and the African Direct Telegraph Company for messages to Sierra Leone, either *viâ* Cadiz or *viâ* St. Vincent, is 6s. 9d. per word.

The "Dacia," having completed her portion of the work, is now on her way home, and the "Buccaneer" is now laying the shore ends at Grand Bassam, Accra, and Porto Novo for the West African Telegraph Company's cables.

The "Silvertown" sails on Saturday with the deep sea part of these sections, and with sufficient cable to continue the West African Telegraph Company's system from Porto Novo on to S. Thomé, Principe, Gaboon, and S. Paulo de Loanda.

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ORIGIN OF THE ELECTRIC DISCHARGES OF THUNDER CLOUDS.

M. D. Colladon, in a paper to the *Academie des Sciences*, says it is a well known fact that electric potential constantly increases as we ascend from the earth, and we suppose that a positive electrification reigns in the upper regions of the atmosphere.

M. Palmieri attributes the abundant production of electricity in the storm clouds to the condensation which draws the aqueous particles into drops of rain, and he thence concludes that every cloud which resolves itself into rain is a continual source of electricity.

Now experience shows that the condensation of water does not produce a notable amount of electricity, whilst it is a fact generally demonstrated at all seasons that the layers of air above the clouds are positively electrified in respect to the earth.

M. Faye thinks that the origin of the permanent electrification of the thunder clouds is caused by a continual descent of the layers of air above these clouds; but he seems to attribute the descent always and only to the gyratory and translatory movements which are, he says, always taking place during storms.

The author does not agree with this latter point. He says that the continual observations of electric storms, which he has carried out for 60 years, as well as those given by many other observers of stationary electric storms, accompanied by hail, oblige him to admit that, as well as the great storms engendered by gyratory motion of the atmosphere, and passing rapidly from one place to another, there are others just as numerous, perhaps more so, where the storm cloud remains long stationary, and where the descent of the upper layers of air is essentially due to a shower of rain, apparently the sole cause of the incessant renovation of the electricity of the clouds and sometimes also of the freezing of their drops of rain into hailstones.

The author proceeds to state the ground of his belief that the descent of the upper layers of air is caused by the rain, and he thus explains the frequent continuance of the thunder clouds in a state of strong electric tension unceasingly spent and renewed. Every nearly vertical fall of water produces a wind directed towards the earth. All waterfalls produce a strong current of descending air, which spreads itself out over the ground, and gives birth to what has been called the *vent des cascades*. This wind for large falls of water forms in certain cases a veritable tempest near the foot of the fall.

In the same way each drop of rain is the source of a vertical elementary current of air, which takes it birth at the very point where the rain begins to fall—that is to say, in the interior of a cloud. The larger the volume of the drop the greater the current of air. Thus every shower necessarily drags with it a descending wind whose source is in the same cloud as that of the drops of rain; and the more heavy the shower the greater the intensity of this wind.

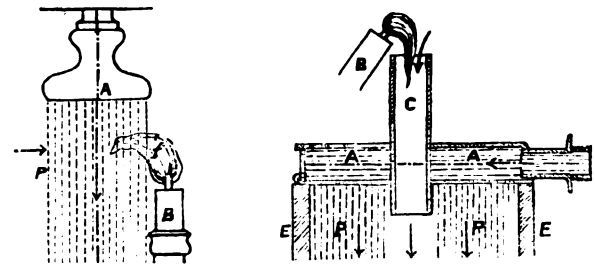
The rain continues to drag the air with it more or less as long as it continues to fall, so that it is only set free when it reaches the earth, and then escapes laterally without being able to re-ascend. There will necessarily be produced, then, in this cloud and at the source where the rain is formed, a considerable atmospheric depression, which must certainly be compensated by an attraction of other air which can only come laterally or from above. When the shower is of considerable extent, towards its centre it must be from above only.

When the rainy clouds are very dense and high up—which is frequently the case in summer—the air attracted from the upper regions ought to bring with it a provision, constantly renewed, of positive electricity, of needles of ice from the cirrus and little globules of water in the state of surfusion. This mixture of ice needles and of globules of water below zero will be more than sufficient to counterbalance the heating of the upper air, which will be produced by its increase of density, and the mean temperature of the rainy cloud might fall considerably below zero. The author thinks that the following facts thus receive an explanation:—

First.—The rapid renovation of the electric tension in most storm clouds, despite the continual discharges of their electricity in the earth, whether these manifest themselves by a succession of lightning flashes, or take place in an invisible manner in consequence of the great electrical conductivity of the lower air strongly charged with rain and moisture.

Second.—The accidental formation of hailstones, which make their appearance more especially in the months of July and August, when the storm clouds are most dense and elevated.

The figures show experiments which illustrate the drawing down of the air by a fall of water. Fig. 1 represents the rose of a watering pot, from which the water descends vertically. If a lighted taper is brought close up, as shown, the flame will be seen to be attracted into the column of water drops. Fig. 2 represents an apparatus which the author has had constructed to imitate, on a small scale, the drawing down of the upper air, which showers of a certain extent produce above the area from which they start. In this apparatus the rose of the watering pot is replaced by a reservoir, A, which has the form of a flattened cylinder of large diameter. The bases of this cylindrical reservoir are traversed normally by a central tube open at both ends. The numerous holes, pierced on the under face to produce the shower, surround this central tube. Finally, an exterior cylindrical envelope of stuff, E E, serves to prevent any lateral attraction of air. The reservoir A being placed horizontally, if we pass water into it the rain which



falls produces an inspiration of air through the tube, which can be rendered visible by bringing near the top of this tube a lighted candle, as shown in the figure.

ELECTRIC TRAMCARS.

The editor of the *Centralblatt für Electrotechnik* says that lately he had the opportunity of being present at the trial trip of Herr Huber's first electric tramcar in Hamburg. This tramcar is constructed after the Julien system, which was distinguished at the Antwerp Exhibition with the first prize or great diploma of honour. Thus the electric vehicle was brilliantly victorious in the competition over the locomotive, a result which would not have been thought possible a few years ago.

Among the definitions of requirements for the competing systems were the following:—Freedom, more or less perfect, from escaping steam; freedom from smoke and sparks; freedom, more or less perfect, from noise; an exterior agreeable to the eye; facility with which the motor can be detached from the carriage; arrangement of the brake so that this may act upon the greatest possible number of wheels of the vehicle or train; disguise of the motor, so that it may be hid as much as possible from the public eye, although it is easily accessible and manageable in all parts for the machinist; ease of intercourse between the driver and conductor of the train; protection of the working parts against dust or dirt, evenness and quietness in the motion; arrangements to go round curves of small radius; simplicity of construction; the relation of the dead weight to the number of seats; facility with which the motor can be got ready for service; the greatest possible daily length of service without other detention than that which is required by the service; working expenses per carriage, and per kilometre; the smallest use of burning materials, and the same of lubricating materials.

The electric carriage was considered to most nearly meet all these requirements. Even in the matter of consumption of burning material the indirect electric working of the motor was found cheaper than the direct steam working, because cheap pit coal could be employed instead of the more expensive coke.

The Julien system concerns, first, improvements in the accumulators, and second, the contrivance of the car. The improvement of the accumulators consists in that the lead is replaced by a metal composition called Julien metal, which secures a greater endurance of the accumulators.

Mr. Huber has entered into association with the directory of the Hamburg Roadway Company, whereby shortly two electric cars will be tentatively worked. The one which we are describing contains 33 seats, and weighs with full equipment 4,830kgs. Of this weight 1,200kgs. is that of the accumulators. The accumulator consists of 96 cells, of which every three are united in a single three-celled holder Glass and brittle substances have to be dispensed with for fear of breakage. The cells are formed out of a new material, something like hard gutta percha but rather more flexible. Each cell contains 15 plates, seven positive and eight negative. The plates have a surface of only 134 by 147mm., and are about 4mm. thick. The charging requires about eight hours.

The accumulators are distributed in eight low wooden boxes, of which four are stowed away on each side of the car in the space under the seats. The boxes move along greased slides, and can easily be drawn out by opening two long traps in the side of the car. In the car house the vehicle is drawn between two tables, on which the charging takes place, and the accumulators are slid from the car on to the tables. The shunting of the boxes, both in the car and on the charging table, takes place automatically by a contact apparatus both simple and sure, constructed by Mr. Huber.

Four double conductors lead from the accumulators in the car, which are shunted in four groups, to the Julien commutators, of which one is placed on each perron. By turning a handle which forms part of the key of the commutator six different positions can be given to it, viz.:—

(1) So that there is no connection between the accumulators and

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the motor. (2) The four groups of accumulators are shunted in parallel arc and placed in connection with the motor. (3) The groups are shunted two and two in parallel arc, and the two pairs in series and in connection with motor. (4) Two in parallel arc behind the other two in series. (5) All four groups in series. (6) All four groups in parallel arc, but unconnected with the motor. The commutator stands in this position with the key up during the periods of stoppage.

A great advantage of this arrangement is that different velocities are obtained without the application of any current regulator or resistances.

The positions (2), (3), (4), (5) of the key correspond to the E.M.F.'s 48, 96, 144, and 192 volts on the motor, and its velocity again corresponds to these E.M.Fs. The normal current amounts to about 18 amperes, while on inclines and curves the current may sometimes reach 80 amperes. The motor is a Siemens series machine, model D, with about 0·6 ohm resistance, which is hung under the car, and gives out its power by means of hemp cords to a blind axle between the two wheel axles, and from hence the power is given out by means of chains to the wheel axles. The hempen ropes are protected as much as possible against the influences of weather by a special preparation.

The reversal of the direction of rotation of the machine is brought about by changing the position of the brushes; there are two pairs of brushes about 90 deg. apart, of which only one pair rubs at one time.

One charging is sufficient to drive the car 50km. Since such a car has to traverse about 100km. daily, one change of the accumulators is enough.

The charging of the accumulators is performed at the inn of Schürbeck. Here there is a little machine house built on, with a Lilienthal motor of 10 horse-power fastened to the wall, which receives its steam from a little boiler with a hose. The steam engine is condensing and works extremely economically. It drives at present one contact-machine of Schwerd of Connstatt. The velocity is controlled by a Tachometer of the Buss system, whilst the electrical quantities are regulated by instruments of Paterson and Cooper, Breguet, Ayrton and Perry, and Manuel. These instruments differ by 20 to 30 per cent., whence the value of their indications appears to be somewhat doubtful.

The trial trip passed off brilliantly. The coachman showed that he knew well how to manage his electric horses. A trial on the efficacy of the brake at great speed gave a surprisingly good result. The motion of the vehicle was essentially quieter and pleasanter than one is accustomed to in horse-tramways, also quieter than on the Frankfort electric tramway. The violent jerks, which are very unpleasantly noticeable at starting in the Frankfort car, are not present in the Hamburg one. The car starts softly, and the increase of velocity takes place almost uniformly.

SOUTH KENSINGTON EXAMINATIONS.

(Continued from page 142.)

Voltaic Electricity.

10. How could you boil water by means of the current from a voltaic battery? Give a sketch of the apparatus you would use.

A.—Join the thick copper wires A C and B D coming from the opposite ends of a powerful voltaic battery by means of a coil of thin wire of some metal having a high resistance, such as platinum or iron, and place the coil in a small vessel filled with water.

Owing to the resistance of the coil of thin wire being very great compared with that of the rest of the circuit, the greater part of the heat generated by the action of the current flowing through the circuit will be evolved in the coil, and if the battery be a powerful one, and the quantity of water not too great, the heat generated will be sufficient to make the water boil in a short time.

11. One end of a copper wire is fastened to the copper end of a battery, and one end of copper wire is fastened to the zinc end of the battery. What happens if the other ends of these two wires are put side by side (but not touching) into a solution of sulphate of copper?

A.—1. Owing to the circuit being completed by the solution of sulphate of copper, a current of electricity will be set up, flowing from the copper end of the battery through the solution of sulphate of copper, as shown by the arrows.

2. The sulphate of copper will be decomposed.

3. The copper, which will be liberated at the end of the wire connected with the zinc plate, will be deposited on the immersed portion of that wire, while sulphuric acid (hydric sulphate) will be formed in the neighbourhood of the wire connected with the copper

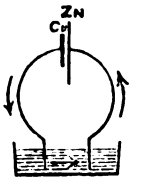
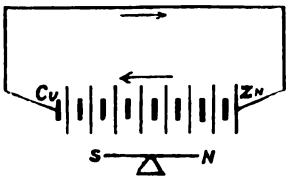


plate of the battery, and will gradually dissolve the immersed part of that wire, and so keep up the strength of the solution.

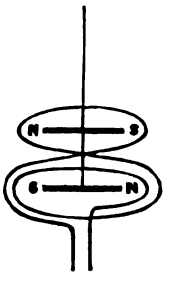
12. A number of galvanic cells are connected together in a row so as to form a battery. This row is laid on a table so as to lie N. and S. The zinc is to the N. The poles of the battery are connected together by a wire, which passes from one pole, up one wall of the room, across the ceiling, and down the opposite wall to the other pole of the battery. How will a magnetic needle be affected which is placed under the table and just below the battery?



A.—The magnetic needle, being immediately underneath the battery, will be acted on by the current flowing through the battery, and will not be sensibly influenced by the distant current flowing in the opposite direction across the ceiling.

As the current through the battery is flowing from north to south over the needle, the north seeking end of the needle will be deflected towards the east.

13. How is it that a galvanometer with astatic needles is more sensitive than the same instrument would be if furnished only with a single needle?



A.—If two magnetised needles, equal in every respect, and equally magnetised, be fastened rigidly together with their axes parallel, and their corresponding poles pointing in opposite directions, as shown in the diagram, the earth's magnetic force will have no directive power on the combination. If such a combination were used in a galvanometer, the only directive force determining its position of equilibrium when no current was passing, would be that due to the torsion of the suspending fibre. By using a fibre in which only a a small restoring force was called into play by its torsion, the combination could be made very sensitive to the action of even very weak currents.

It is, however, practically impossible to manufacture such a system, for even if the needles, to begin with, were magnetised to an exactly equal extent, and were fixed perfectly parallel, one of them would almost certainly in time become weaker than the other.

In practice, therefore, we generally use two needles, one of which is magnetised somewhat more strongly than the other, and therefore the combination will take up a position of equilibrium in the plane of the magnetic meridian (supposing a suspending fibre be used whose torsion does not produce an appreciable restoring force) in obedience to the action of the more strongly magnetised needle; but the restoring force called into play when the combination is deflected out of the plane of the magnetic meridian, depending as it does on the difference of the earth's directive action on the two needles, can be made very small by magnetising the two needles to very nearly an equal amount, and therefore a very weak current will be sufficient to produce an appreciable deflection.

In the second place, the wire being wound round the needles, as shown in the figure, it will be seen that the effect of the current

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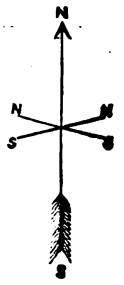
upon each of the needles will tend to deflect the combination in the same direction. Thus we see that a galvanometer with an astatic combination of needles is more sensitive than it would be with a single needle. Firstly, because the earth's directive action upon the combination is less than it would be upon a single needle. Secondly, because the deflecting action of the current upon the combination is greater than it would be upon a single needle.

Remarks.—There is another form of astatic galvanometer in which the two needles are fixed together in the same way except that they are not quite parallel, though very nearly so.

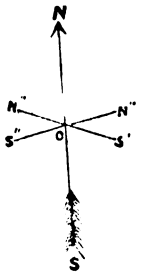
When we look down from above on such a combination we shall see the two needles projected upon a horizontal plane, as shown in



the accompanying figure, where the want of parallelism is very much exaggerated for the sake of clearness.

It is easy to see that if the two needles were magnetised with exactly equal strength, such a combination would take up a position of equilibrium with the plane of the magnetic meridian bisecting the vertical planes drawn through the needles, as shown by the arrow in the diagram.

If one of the needles N′ S′ be rather more strongly magnetised



than the other one, N″ S″, the combination will set itself so that the angle N′ O N is somewhat less than the angle N″ O N.

As, however, the two needles are very nearly parallel, and as nearly equally magnetised as possible, the combination will set itself so that the two needles are sensibly perpendicular to the plane of the magnetic meridian.

14. If a charged battery is to be kept for some time ready for use, why is it important to take care that the ends of the battery are not connected together outside the battery?

A. If the ends of the charged battery are connected together outside the battery, the circuit will be closed, and therefore an electric current will be set up, accompanied by chemical action in the battery and a consequent waste of material.

(To be continued.)

LIGHTING EXHIBITION AT BRUSSELS.

The Belgian Society of Engineers has opened in the Brussels Bourse an interesting exhibition, both modern and retrospective, of apparatus for illumination, including old Grecian oil lamps, the first oil lamp that lighted the streets of Paris, a quantity of old candlesticks, recent improvements in lighting by gas and petroleum, and a few elegant applications of the electric light. An interesting historical object is the first Foucault regulator, borrowed from the laboratory of the Brussels Municipality, which served to light up the Rue Royale, Brussels, on the occasion of the twenty-fifth anniversary of national independence in 1855. The square, horizontal carbons are mounted on trucks working on incline planes, being regulated by clockwork connected with the electro-magnet.

The Brussels company, "L'Electrique," whose automatic electric tramcar gained the diploma of honour at the Antwerp Exhibition trials of last year, arranged a small lighting installation to show the several applications to houses, offices, and vessels. The fittings, with fusible plugs and bayonet joints for the glasses, are very strong, and yet present an elegant aspect. One lamp for domestic purposes has a coloured glass enclosed in an opal globe, for use where a strong light is not required, so as to preserve the sight. A passage or hall lamp is covered by a trunco-conic glass in the form of a shield or rather buckler, cut with innumerable facets for distributing the rays. In the centre, where the light is strongest, the glass has a boss which still more effectually diffuses the light. An office desk is provided with a movable standard, carrying a shade and two incandescent Lane-Fox lamps of about 12 candle-power, the current for which is supplied by a small battery of twelve accumulators, having plates of amalgamated lead, which is stronger than ordinary lead and lasts much longer. These accumulators, which are contained in one of the compartments of the desk, are of the same type as those used for the electric tramcar at Antwerp. A four-branch lustre and a pendent electrolier produce an agreeable effect, while another form of lamp with shade attached to the wall, resembles an ordinary gas bracket, contacts being made by switches in the form of stop-cocks. An electric torch consists of a Lane-Fox incandescent lamp fixed to a handle and protected from injury by a wire cage, so that it can be thrust into corners without fear of breakage. The conductor, which passes through the handle, is strong, flexible, and well covered.

Besides some miners' safety lamps, with electrical means for the detection of firedamp, M. Léon Somzée has sent his apparatus for the production of light by incandescence and by infinitely small arcs. The exciting organs consist of but slightly conductive and extremely subdivided substances, such as metallised carbon powder and combustible gas. It combines the advantages of the arc and incandescent systems—that is to say, economy, divisibility and intensity—while, at the same time, ensuring continuity of the circuit, rendering the light relatively independent of variations of the current, and obviating a too great concentration of luminosity.

M. Somzée also exhibits his automatic regulating lamps, in which the arc and incandescent systems are again combined. The principle consists in producing incandescence in a thin carbon, and developing the voltaic arc round a *colombin** fixed to the second rheophore, which is of large sectional area. This arrangement gives an arc light terminated by the incandescence of the carbon. The arc is invariable, for its resistance depends on the ratio of the sections of the *colombin*, and of the incandescent carbon, this ratio being absolutely constant. The arc is practically uniform, for its development is guided by the *colombin*; and the carbonaceous mass is directed towards the interior of the arc. The wasting away chiefly takes place from the thin carbon, its replacement being effected automatically without the aid of mechanism. It follows from the fact that the arc is developed round the *colombin*, between the carbon and the large block, that the tension current may have a large surface for a given sectional area of carbon, so that both the conductivity and the duration of the carbon increase. The luminosity is considerable, seeing that it is an arc lamp that can be maintained by a continuous current, while the light may also be divided. The interposed refractory substance may be movable, in which case its degree of volatilisation or disaggregation is independent of the wear of the large carbon. It may, on the one hand, be fixed, in which case it must disappear concurrently with the combustion of the carbon. In either case the extent of the arc, and, consequently, the intensity of the light, may be as great as can be maintained by the current at disposal, without the resistance varying or exceeding the assigned limits on account of the thickness of the insulating substance.

M. Léon Lennaerts has installed two appliances constituting a happy combination of gas with electricity. In case a fire should break out in a building lighted, in the ordinary manner, by gas, it is the main gas supply which constitutes the greatest danger. M. Lennaerts has succeeded in closing the meter automatically, and also in utilising this motion of the lever for so setting a switch that the current from a secondary battery or dynamo shall light up some incandescent lamps, where otherwise darkness might prevail through the cutting off of the gas supply. This is brought about by the lever of the gas meter, which is counter-weighted, being held in the position of "open" by a fusible wire, and its fall, on the wire being fused by the current, working the switch which sends the current through the lamps. In order to inspire the utmost confidence in this arrangement, a safety lead, consisting of two wires kept apart by a combustible insulating substance, is disposed about the building, so that contact is made automatically on a fire breaking out.

M. Lennaerts' other apparatus is for electrically opening or closing the main supply of gas from any desired point or points, without the necessity of going down into the cellar, owing to which trouble so many meters are never closed at all. Moreover, as soon as the stop cock is closed, any burner that may not be turned off gives warning of the fact by an electric bell, which continues to ring until the matter is set right, while an indicator shows exactly which burner is not turned off.

The Société Nouvelle des Produits, of Namur, shows some enamelled sheet iron reflectors of various forms for electric lamps.

* An intermediary non-conducting substance.

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PROF. FORBES' CANTOR LECTURES.

LECTURE V.

I commenced my last lecture by showing you the remarkable experiment made by Prof. Œrsted. This experiment has been spoken of by some as having been an accident. At the moment that he saw the influence which a wire carrying a current had upon a magnet, he was trying to detect the influence in a totally different manner. He was trying to detect the influence of the heat generated in a wire upon a magnet. Instead of finding that, he found the remarkable result which formed the basis of our demonstrations in the last lecture. I say by some it has been said that Œrsted's experiment was the result of an accident. I protest against any such interpretation being put upon it; it shows comparatively feeble knowledge of the means of progress in scientific discovery. It is by such constant labour and the readiness to grasp all unexpected phenomena that present themselves that the greatest discoveries have been made. Were we to say that the philosopher studying in his laboratory after numerous experiments happens to come across something that he never knew before—were we to say that that was an accident, why then we should have to say that the discovery of the planet Uranus was an accident, and the discovery of many continents and islands over the world were accidents; in fact, that half the discoveries of philosophers in their laboratories had been accidents. As the result of that brilliant discovery of Prof. Œrsted we saw last week that several conclusions could be drawn—the continuous rotation of a magnetic pole round an electric current, the motion of a wire carrying an electric current in the neighbourhood of a magnet, and the attraction or repulsion of two parallel currents, according as they were in the same or in opposite directions. The discoveries of Faraday and Ampère are necessary conclusions from Œrsted's experiment. At the same time, that does not detract from the originality or the merit of these great men, who followed out the experimental work, and proved the truth of those facts which were new to science. And so it is in the present day. Frequently we find new discoveries which, upon investigation, are found really to be deducible from what we knew before; but that in no way detracts from the merits of those investigators who, by their laborious researches, have introduced to us facts which at the time were new to science. And especially is this the case in electrical science. Frequently we have new facts presented to us that none of us were before acquainted with, and it is common for us to say that such facts were deducible from the known theory of electricity. That may be so, but it does not detract from the value of these new researches. I will, with your permission, before going on to the question of induced currents, which is a continuation of the deductions which may be made from Œrsted's experiment, illustrate the subject of the last lecture by means of a different apparatus, of great beauty, and one which, with the same fidelity, proves the truth of the rotation of a current of electricity round a magnet. I have here a globe partially exhausted of air. The density of the air within this globe is very much smaller than the density of the atmosphere around us. I shall pass a current of electricity through this globe, passing it along the outside of the tube, which you see going down from the top through the middle of the globe. Within that tube I have a piece of iron with a coil round it, so that with the wires connected to the battery I am able to magnetise that central piece of iron either with the north pole downwards or with the south pole downwards. We saw before by numerous experiments that when a current is travelling parallel to a magnet it tends to rotate round it in one direction or another, according to the direction of the poles of the magnet. In the experiments in connection with my last lecture we always used a solid body—generally a copper wire—to convey the current of electricity. In this case I am going to pass the current through attenuated air. Now, when we send a current through this induction coil you see a current of electricity passing parallel to the magnet from the top down to the bottom. [Shown.] I am now able, by means of a commutator which is on the table before me, to send a current through the coil within the tube in either direction, so that I can magnetise that bar of iron in either direction at pleasure. I will magnetise it with the north pole downwards, and you see a continuous rotation of the electricity round it. I will now reverse the direction of the magnetisation, and put the south pole downwards in place of the north pole, and the current stops, and then commences to revolve in the opposite direction. [Shown.] All the phenomena of movement of a wire carrying a current were shown in the last lecture to be due to the presence of a magnetic field. The wire itself acts in such a way as to create a magnetic field in its neighbourhood. The magnet itself, however, may be looked upon as an agglomeration of electric currents, and I showed you a model giving the ideal magnetic molecules. Let us consider the question now of Œrsted's first experiment, or one of the experiments that follow directly from it. I will take a coil of wire with a magnetic pole in its neighbourhood. When we pass a current of electricity through that coil it moves the magnet—moves it against the force of terrestrial magnetism which is trying to hold it in its place. Now, the principle of the conservation of energy proves to us that a motion like that of a magnet towards the coil or away from it cannot take place without the consumption of energy. I have a current of electricity passing through this coil, and as soon as I bring it near to the magnetic pole energy is consumed. What is the energy which is consumed? Where does it disappear from? Clearly it must disappear from the energy of the current which is circulating in the coil. In other words, when the magnetic pole approaches the coil the energy of the current is diminished. The diminution of this current on the approach of the magnet towards the coil simply means that an inverse current is tended to be set up by the approach of the magnet; in other words, by a consideration of the principle of the conservation of energy we are able to deduce from Œrsted's experiment this remarkable fact, that when the pole of the magnet approaches the coil, a current is generated in the coil by the influence of their mutual approach. However desirable it may be to trace the connection between all these different phenomena, the facts themselves must be demonstrated, and we must see the experiments before us in order to convince ourselves of their reality. I have upon the mantelpiece there a small galvanometer, which consists simply of a suspended magnet attached to a highly polished mirror, and placed in the centre of a coil of wire which surrrounds the magnet. When the limelight is thrown upon it it will deflect a beam on the scale which you see on the wall there. The vertical wire is placed in the position which would be occupied by the slide of a magic lantern, so that we should have the image of the wire moving upon the screen in accordance with the motion of the magnet within the coil of wire. The ends of the coil of wire are carried away here [indicated], and are continuously connected together, so that that coil of wire has at present no ends, for the two ends come over here, and are coiled up in half a dozen parts. I hold in my hand here a magnet with the north pole pointing towards you at the present moment, and my object in this experiment will be to prove the truth of the deduction that we made just now, and to show you that by the approach of the magnet simply into a coil of wire like that we are able to induce a current of electricity in the wire which will circulate round the coils of the galvanometer, and so deflect the compass needle. [Experiment.] There you see the bar slightly oscillating, owing to a slight movement of the compass needle. At the present moment it is my intention to reverse the north pole of the magnet within the coil of wire, and as I do so the spot of light moves towards the right. When I move the north pole into the coil of wire in this direction the spot of light moves to the right, and if our theory be true it would immediately follow that on the withdrawal of the north pole from the coil of wire we should get a motion in the opposite direction. I withdraw the magnet, and the spot of light moves to the left. I will now introduce the south pole instead of the north. I force the south pole in, and the spot of light moves to the left—the opposite direction to what it did before. [Shown.] I will now complete the set of experiments by withdrawing the south pole, and the spot of light in this case ought to go to the right. [Shown.] There are a vast number of experiments which were undertaken by Faraday, who made this brilliant discovery, explaining the application of these general principles. And just as we have found that that experiment with a magnet and a coil is a direct result of the brilliant experiment of Prof. Œrsted, so we shall see that other experiments which were performed by Faraday are the necessary and natural consequences of the results arrived at by the French philosopher Ampère. Ampère found that when two coils of wire were placed in proximity to each other, and currents of electricity were flowing through both, there was attraction or repulsion between them according as the direction of the currents of electricity were the same or opposite to each other in the two coils. Exactly similar reasoning to that which I used a short time ago upon the principle of the conservation of energy proves to us that this energy which is thus used up is derived from the energy in the currents, and that at the moment of the approach of the two coils there must be a diminution in the strength of the currents of electricity; and if there be a current of electricity in only one of the coils this approach of the two coils together must cause the creation of an inverse current in the second coil. I have connected now one coil to the galvanometer, while the other is connected with a commutator here, by means of which I am able to send a current of electricity through it. At the present moment there is no current passing through it. I have now got a current passing through my coil, and I approach the coil towards the one which is connected with the galvanometer. As I approach it the spot of light is moved to the right. That shows the creation of a current in an induced coil inverse to the direction of the current in the inducing coil when the spot of light went to the right. When I withdraw the two coils we ought in the same way to see a motion of the spot of light to the left. I will now reverse the current of electricity, and the opposite effects ought to take place. We shall now be able to prove that a current induced in a second coil is always in the opposite direction to the inducing coil. [Showing.] I approach them and the motion of the spot of light is to the right. In conclusion, I will show you next that when I keep the two coils together and make or break a circuit the same effects take place. I first make the circuit and the spot of light moves to the right. That is equivalent to the bringing of the two coils together. I will now break the circuit and the spot of light moves to the left, which is equivalent to the opposite effect of withdrawing the two coils. [Showing.] There is one more experiment that I will show you in connection with this, and that is the enormous influence of the introduction of a bar of iron into these coils. We have seen that the whole of these electro-magnetic effects are due to the production of magnetic fields in the neighbourhood of the wires. If, then, I introduce a bar of iron partly into the secondary and partly into the primary coil, and then make and break the circuit, the spot of light will be found swinging right round. [Showing.] Faraday worked at this experiment a great deal, and tested the accuracy of his conclusions in a variety of ways. It is all very well for us just to look at a few experiments like these, and to say that they are the necessary conclusions from Œrsted's experiment. But that is not sufficient to convince the philosopher when he is for the first time investigating these new facts, and it was the laborious study on the part of Faraday that completely established the whole of the truth of the laws of induction. Faraday showed that the terrestrial magnetism was sufficient to induce a current of electricity in a moving wire, and it is evident that this must be the case. I will show you that it is so by means of this apparatus which I have here. I will place this coil of wire so that I can rotate it about a horizontal axis which will cut the magnetic field created by the earth's magnetism. The lines of force in the earth's magnetism in a horizontal plane are going in a direction perpendicular to the axis about which I rotate the coil. You see, then, that at any one moment while this half

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of the coil is cutting the lines of force in one direction the other half is cutting the lines of force in the other direction. It follows from this that a current of electricity will be created in the one half of the coil from your left to your right, and in the lower half of the coil it would be at the same time from your right to your left. The combined effect of this is always to produce in both parts of the coil a continuous current in one direction round the coil. But after this has been accomplished at one half of the revolution the tendency during the other half revolution is to create a current in the opposite direction. It would be in the same direction in space, and therefore in the opposite direction in the wires. In order to get over that difficulty, what is called a commutator is introduced here, by means of which the direction of the currents which are taken away here to the galvanometer are reversed at each half of the revolution. Thus, if there is a reversal of the direction of the current in the coils of wire at each half of the revolution, and also a reversal of the connections of the two wires to the galvanometer. the current through the galvanometer must remain always in the same direction, and thus by turning the handle rapidly we are able to add together the effects of half rotations, and we shall have a continuous deflection of the spot of light on the scale. I will rotate this coil, and you see a movement of the spot of light to the right. I will now rotate it in the opposite direction, and it moves to the left. I will get up a swing now to the right and to the left, rotate to the right and rotate to the left, and by showing that swing you are able to show perfectly easily the creation of these currents of terrestrial magnetism. I will intensify your belief in this by causing the spot of light to come to rest. [Shown.] The generation of currents of electricity by this means—that is to say, by the motion of a magnetic field and the motion of a wire in a magnetic field—has given rise to practical applications of the very highest importance, and when speaking of those powerful currents of electricity which are created by our dynamo machines I will show this. But I may at least introduce one illustration here of the intensity of the currents which can be so induced. I have upon the table an apparatus consisting of a horseshoe magnet with soft iron pole pieces, and around these pole pieces are ribbons of wire, and there is a keeper placed upon the poles here at the ends of the pieces of soft iron. Thus at the present moment there is an intense degree of magnetisation in these iron cases round which the coils of wire are placed. If I suddenly remove the keeper from the magnet I diminish the amount of magnetisation in the soft iron pole pieces to a very great extent. This change in the intensity of the magnetism inside the coils is equivalent to the passing of lines of force through these coils. The result of this diminution in magnetism is to create an intense E.M.F. in the wires. That E.M.F. which is created may be utilised for several purposes. At the present moment I have placed upon it one of those fuses generally known as Abel fuses, from the name of our president, who constructed them for explosive purposes, and for use in mines, and the current of electricity which we shall be able to get simply by withdrawing this keeper from the magnet will be able to explode the fuse, which is connected to the wires which surround the soft iron poles. [Shown.] You all saw the explosion from that little detonator. That, I need hardly say, is a current of very great intensity indeed, of very short duration, but very powerful during the short time it lasts, and capable of overcoming a very great resistance.

There are many other experiments illustrative of induction which I should like to show you. Here is one of a very important character, and very instructive, when we see the reason why it works. I have a copper disc supported upon a vertical axis, to which I have the power of giving very rapid rotation. Above that I have a sheet of glass considerably larger than the copper disc, and not touching it, and fixed upon the centre sheet of glass is a pivot with a compass needle attached to it. When I rotate the copper disc the compass needle is seen to rotate in the same direction. There are no air currents capable of influencing it, because the glass plate shields it from all currents of air. This was a discovery of Ampère, and Faraday was the first to show that it was simply a consequence of these induced currents which he had been investigating. And now let us first see how the explanation is arrived at. Consider that above this north pole a copper disc is moving, and therefore a current of electricity is generated in the copper disc; but when the current of electricity is in the neighbourhood of the pole, it causes that pole to move, and therefore the rotation of the copper disc has the double effect of first inducing an effect in itself, and then reacting owing to the existence of the current upon the magnet pole itself, and so being able eventually to pull it round in the same way. You see the motion of the needle and the force of the earth's magnetism counteracting it; still it is able to overcome the earth's magnetism. Now it is rotating in the same direction as the copper disc, and it is gradually acquiring velocity, and would eventually rotate at almost exactly the same speed at which the copper disc is itself rotating. This phenomenon of Faraday was also examined by other people, and there are a vast number of instructive results which come from modifications of this experiment. I am only going to show you one modification, which was first shown to me by Dr. Guthrie, it is a very striking experiment indeed. I suspend here a horseshoe magnet, so that the poles are just above the rotating copper disc. There is an effect which I wish to show you, which is due to what has been spoken of as electric momentum—that is to say, that the electric current has a species of momentum very much as a moving body has a momentum. I think we are very certain that electricity is not a material substance, yet it is influenced by electromotive force, very much as material substances are influenced by ordinary forces. And there is such a thing as momentum in connection with it—that is to say, a current once created tends to maintain itself. One of the consequences of this is that when we rotate the disc the action, whether attractive or repulsive, lasts for a considerable time, and it does not take place at the same points where you expect it to take place if we did not consider electro-magnetic momentum. If we did not consider this momentum as any point of the copper disc is approached towards the magnet, it would be repelling it. But any point of the copper disc receding from it would be tending to attract it. If there were no electro-magnetic momentum, the upward motion tended to be produced by the approaching part of the plate would be equal to the downward pull of the receding part of the plate. But if there be an electro-magnetic momentum, so that the current once established tends to keep itself going, then the action of the approaching part would be nearer to the pole than the action of the receding part, and therefore the repulsion afterwards would be in excess of the attraction downwards produced by the receding part of the copper disc. [Shown.] It would lead me very far if I were to go on to consider all that is due to the phenomenon of electro-magnetic momentum, but I shall have a few words to say about it presently. I want, however, in the first place to show you an experiment showing the powerful nature of an induced current when a good conducting material is moving in the neighbourhood of a magnet. I have here a copper medal placed between the two poles of a powerful magnet. I shall give this medal a considerable spin. I shall twist the thread which suspends the medal between the poles, and when I have twisted it so that it will maintain the spin for a good long time, I shall allow it to spin freely. As soon as I create a magnetic current by connecting this electric magnet with a powerful battery, this copper medal will be creating induced currents of great intensity, as it cuts the lines of force of the magnetism. The result of that will be that these currents will react upon the magnet, and the magnet will always tend to stop the motion which gives rise to the currents, and, therefore, as soon as I let it spin, and then connect the magnet with the powerful battery, you will see the rotation of the copper medal stopped. It is now rotating rapidly. I make contact, and immediately the rotation of the copper medal is stopped. The higher the velocity it has the greater is the rapidity with which it is stopped. [Shown.] When we use a large mass of metal like this the intensity of the current which is created in it depends partly upon its form and partly upon its conducting power. The greater the conducting power of the metal the greater is the effect of this kind which is produced. Had I used a comparatively bad conducting material, such as lead, the effect would not have been nearly so marked; but by using a highly conducting material, such as copper, the effect was very appreciable indeed. Thus the intensity of induced currents in bodies of the same form, subject to the same inducing influence, depends upon their conducting power. And this property has been utilised by Prof. Hughes in a very ingenious instrument which he has called the induction balance, in order to detect minute differences in metals; and not only so, but he is able to measure the difference of conductivity of different metals, and of the same metal with slight variations of impurities in them. The apparatus I shall be able to show you. But in speaking of induction it is essential that attention should be drawn to this very beautiful apparatus. It consists essentially of two pairs of coils—one pair at each side of the board, one coil rising above the other, with a hollow cup in their centre. When we send an interrupted current through one of these coils, an induced current is created in the second coil by the action of the one through which the battery is sending the current, but there is nothing more than that. In the centre of the coils we have now placed a mass of metal. The currents are now also induced in that mass of metal, and they should re-act upon the secondary coil, too, and the intensity of the reaction can be shown by connecting a secondary coil with a telephone; this was the means by which Prof. Hughes examined it. He got sounds from the telephones which depended on their intensity, and by arranging two pairs of coils in this way and connecting them in such a manner that when there was no metal in the centre of either pair of coils the one counteracted the other so that no sound was heard on the telephone, but so soon as the metal was introduced into the one or the other the balance was disturbed, and effects were apparent on the telephone. And so delicate was this test that the placing in the centre of two coils two sovereigns was actually heard, and he was able to trace a difference in the effect either due to resistance or due to the difference of form or due to the difference of material of the two sovereigns. The two sovereigns being turned out at the same time you might naturally think they were the two likest things in the world, yet they were found to be different by this telephone. I now show you some specimens of copper and the difference of their conductivity upon the scale which you see here. [Indicated.] This specimen low down on the scale is the ordinary commercial copper, and its conductivity is indicated by that short distance [indicated], while high up there we have a higher conductivity of copper which is used for all refined electrical researches and which is nearly pure. The conductivity is represented by nearly three times the distance, while beyond there is a copper which Prof. Hughes found produced a conductivity very considerably in excess of that of the finest copper which had been taken for other experimental purposes. I am afraid the time will not permit me to explain this more recent and exceedingly beautiful apparatus of Prof. Hughes. Perhaps it may be better if I leave it for the present and speak of it in the next lecture. But I will simply briefly allude to this induction bridge, as he calls it, and tell you the object for which it was designed. We all know now that when a current of electricity is passing through one wire, and there is another wire in its neighbourhood, that an induced current is brought about in the other in the opposite direction. If the current came through both these wires simultaneously, each one would at the same moment be tending to create a current in the opposite direction in the other wire. Thus, the current is diminished owing to this mutual influence between the two wires, and this effect arises from their being both conductors. I will simply say that this apparatus was designed for the study of this property of self-induction which is possessed by wires, and it was by means of this apparatus that Prof. Hughes was enabled to enlarge our knowledge very considerably. The lecturer having demonstrated the theory of induction by means of a telephone proceeded to say: I will now show you a few other experiments.

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This induction coil consists of a primary coil of wire wound round a bundle of iron wires; this is connected with a battery, which enables us to make and break contact in succession; and we have alternately a current and no current passing with interruptions. Around that is a high resistance coil of wire, and the making and breaking of the current on the primary with the influence of the iron which is in its centre causes induced currents to be created on the outer coil, creating at the terminals of the two wires an enormous difference of potential, such as we obtain from the Wimshurst machine, which we were examining the first day of these lectures. I will show you the almost continuous charge between these two points, when we make and break the primary circuit. [Experiment.] You see what an enormous length of spark we are able to get. This enormous length of spark is obtained from four cells in the battery, which of themselves could not produce a spark a thousandth part of the length which we are able to get in this way. I will now put a Leyden jar in the secondary circuit. By this means we do not get anything like so long a spark, but we get a much greater quantity of electricity, and the effect is quite as striking as before. Here I have two specimens of glass which were on the table when I was speaking to you about the differences of potential in my first lecture. One is a thick piece of glass 1in. in diameter, which was pierced from the spark of Mr. Spottiswoode's machine. The other piece of glass has been pierced by the machine before you, and it is very beautiful to see the nature of the discharge through the glass. Here I have half-a-dozen of Abel's fuses, which we shall explode altogether at the same time in series. [Shown.] I will now show you—as we have this apparatus on the table—a very beautiful form of discharge. This jar has a conductor from the top, passing through an insulated tube down into the interior of a tumbler, where it consists of a flat disc of metal. Beneath is another flat disc, on which the tumbler is supported. The tumbler itself is made of fluorescent glass, and the discharge cannot pass from pole to pole, but has to mount up and pass over the lip of the cup. [Experiment.]

LEGAL INTELLIGENCE.

United Telephone Company (Limited) v. Bassano and Slater.

The question in this appeal from Mr. Justice North, which came on for hearing on Monday in the Court of Appeal before Lords Justices Cotton, Lindley, and Lopes, was whether the telephone made and sold by the defendants, Messrs. Bassano and Slater, of Traffic-street, Derby, was an infringement of Mr. Edison's patent, which had become vested in the plaintiffs. The considered judgment of Mr. Justice North was given on the 27th of March and was then reported at length. The main point was with regard to the vibrating diaphragm made use of in the Edison telephone, the defendants contending that in their instrument there was no diaphragm within the meaning of the word in Edison's specification or performing the functions of the diaphragm in his instrument. The general nature of a telephone is well known. It may be popularly described as an instrument by means of which the sound waves set in motion by the voice at the receiving station are made to cause corresponding variations of resistance in a continuous electric current so that the current will at considerable distances reproduce the sound waves in the air at the receiving station. The arrangement for, so to speak, converting the sound waves into variations of electric resistance is called an "electric tension regulator." In Edison's instrument the pulsations of the voice strike upon a vibrating diaphragm, which communicates with the tension regulator, the diaphragm being between the speaking tube and the tension regulator. The defendants placed their tension regulator at the base of the speaking tube, which was attached to a board, to which the wires for conveying the electric current were fixed. The plaintiffs maintained that the board was, in fact, a diaphragm within Edison's specification, and performed the part played by the diaphragm in his instrument. Mr. Justice North having held that the defendants had infringed the Edison patent, the defendants appealed. The defendants said they could construct their instrument without the vibrating board, and asked the Court, in the event of the judgment of Mr. Justice North being upheld, to decide whether they would still be infringing the Edison patent if they omitted the board.

Mr. Bigham, Q.C., Mr. Aspland, and Mr. Claud Plumptre were for the appellants; Mr. Aston, Q.C., Sir R. Webster, Q.C., Mr. Moulton, Q.C., Mr. Micklem, and Mr. Dove for the respondents.

The hearing of the appeal was begun last Friday and concluded this morning.

In giving judgment, Lord Justice COTTON said the only question was whether the machine used by the defendants was an infringement of Edison's patent now vested in the plaintiffs. The question was a nice one. The patent was for improvements in telephones, and the essential thing was to have a continuous current of electricity, but varied in intensity from time to time by the pulsations of the voice, so that the current of electricity should reproduce those pulsations at the receiver. This object was attained by means of the tension regulator, and Mr. Edison said he made use of a diaphragm the vibrations of which acted upon the tension regulator by increase and diminution of pressure. In his specification Mr. Edison gave a general description of his instrument, pointing out the position of the diaphragm, but he did not pretend that this was the only way of acting on the tension regulator. He mentioned other possible diaphragms, and did not confine himself to any particular kind. What he said was:—"I would observe that I do not claim generally the transmission and reproduction of sounds by increasing and decreasing the resistance of the circuit, nor do I claim separately any of the parts or arrangements hereinbefore described and illustrated in the accompanying drawings, except as hereinafter mentioned, but I claim as my invention, first, in an instrument for transmitting electric impulses by sound the combination with a diaphragm or tympan of electric tension regulators substantially as hereinbefore described for varying the resistance in a closed circuit substantially as set forth." The questions, therefore, were whether there was in the defendants' instrument a diaphragm or tympan; whether there was a tension regulator substantially the same as Edison's; and whether there was a combination of the tension regulator with the diaphragm so as to perform the operation described in Edison's specification. What was a diaphragm according to the proper construction of the specification? It was necessary to see whether the word was used as a term of art. The scientific witnesses had not taken the word in any extraordinary sense, but they said that, having regard to the addition of the word tympan and to the terms of the specification, the word diaphragm must be taken to mean something capable of vibrating by pulsations of the air moved by the human voice. Examining the defendants' instrument it was clear that the board acted as and was a diaphragm according to the definition given by Lord Justice Fry:—"The ordinary signification of the word diaphragm I take to be a mere partition or separation—something, as one witness said, which separates something from something else." "United Telephone Company *v.* Harrison, Cox-Walker and Co." (21 Ch. Div. at p. 734). Was it a diaphragm within Edison's specification? It was startling at first that the board to which the speaking tube was attached should be acted upon so as to vibrate and communicate the vibrations to the tension-regulator, but experiment had proved that such was the case whether one spoke through the speaking tube or not, and whether the voice was directed to the front or the back of the board. It was clear, therefore, that in the defendants' instrument there was a "diaphragm." Then was there a tension regulator substantially such as was described in Edison's specification? In his lordship's opinion there was. Edison had mentioned several sorts of tension regulators, but in that which had ultimately been preferred there were fixed blocks and suspended pencils of carbon which acted by varying the tension according to the distance between the carbon points. Substantially the same thing was used in the defendants' instrument, though the carbons were fixed to the base of the speaking tube instead of being situated, as in Edison's instrument, on the other side of the diaphragm. In his lordship's opinion the defendants' instrument was an infringement of Edison's patent, and it was not the duty of the Court to point out the exact particular of the construction to which the infringement was due. The Court would therefore not say whether the defendants' instrument would still be an infringement if the diaphragm was removed.

Lord Justice LINDLEY, in concurring, observed that the only point of difference between the instruments was that the defendants put their tension regulator between the voice and the vibrating diaphragm, while Edison put his on the further side of the diaphragm. It was no good for the defendants to say that they did not want the vibrating board. The answer was, "Then do not use it." In fact, the defendants were using a diaphragm and infringing the plaintiffs' patent. As to whether they would be infringing if they got rid of the vibrating board that question could be discussed when it arose.

Lord Justice LOPES was of the same opinion, and the appeal was dismissed with costs.

We have taken *The Times* report of this appeal.

COMPANIES' MEETINGS & REPORTS.

Australasian Electric Light, Power, and Storage Company (Limited).

An extraordinary general meeting of the shareholders of this Company was held last Monday at the offices, 41, Coleman-street, Bank, to consider, and if thought advisable to confirm, the special resolutions passed at the extraordinary general meeting on the 11th ult. for approving, *inter alia*, the indenture, dated May 20th last, made between Edison's Indian and Colonial Electric Company (Limited) of the first part, Thomas Alva Edison, of Menlo Park, New Jersey, United States of America, electrical engineer, of the second part, and this Company of the third part. The object of the indenture, in brief, is to effect an amalgamation between the Company and the Edison Company. Mr. Benjamin H. Van Tromp presided.

The CHAIRMAN: Gentlemen, you may remember that at the last meeting when these special resolutions were submitted and approved, we were not quite aware whether the Edison Company would, on the same day, pass a series of special resolutions having the same object. I am now in a position to inform you that those resolutions were duly passed unanimously by the Edison Company, and I have no hesitation whatever in saying that we believe that they will be equally unanimously agreed to to-day. All that we have, therefore, to do is to ask you to be good enough to confirm to-day by your vote the resolutions which you passed at the meeting held on the 11th of June. I do not know that I need read them, but I will take them *seriatim*, as before. He then proceeded to submit the resolutions.

Mr. JOHN JAMES CATER seconded every resolution, and they were all unanimously confirmed.

The CHAIRMAN: Gentlemen, that concludes the business. I am very much obliged to you for your attendance, and I can assure you—having regard to the fact that you have been good enough to confirm these resolutions, enabling the Directors to complete arrangements with the Edison Company—that they will do all they can in your interest to make the

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arrangement a good and profitable one for the shareholders of the Australasian Company.

Mr. PEEK proposed a vote of thanks to the Chairman and Directors for having carried out so well the arrangement which had been so long in hand. The task had been an onerous one, and in some respects difficult; but he had watched the proceedings all along, and though in some respects the original proposals had been modified, he thought that from the explanations he had received the modifications were rather in favour of the Company than otherwise. Anyhow, he thought the thanks of the shareholders were due to the Directors for their pluck and assiduity, and for the way in which they had—he would not say dragged the concern out of the mire, but certainly placed it in a much more favourable position than it was in 18 months ago. He hoped that what they had done would lead to making the Company, if not the great success originally anticipated, yet much more prosperous than it was at present. Of course, that would be a work of time, but he wished to thank the directors for what they had at present done.

The CHAIRMAN: I desire to thank Mr. Peek for the kind observations he has made, and having regard to the fact that that gentleman is the largest shareholder in the Company (he holds between 3,000 and 4,000 shares), and that he has devoted a great deal of interest, not only in consequence of that, but also because he is a man of business, in watching the progress of the Company, I need not say with what intense gratification it is to me and my co-Directors that we hear such observations falling from such a gentleman.

Mr. PEEK said he also desired to thank Mr. Duncan, who had laboured with so much assiduity in the interests of the Company. Whenever he (the speaker) had called at the offices for information, Mr. Duncan had put before him very lucidly the points on which he had desired information.

Mr. CATER said he did not know whether the shareholders had noticed that heavy rains had fallen in Australia. He should think that that would greatly benefit the colony, and give a better tone to business there.

The proceedings then terminated.

Edison's Indian and Colonial Electric Company (Limited).

An extraordinary general meeting of the members of this Company was held at the offices, 4, Lothbury, last Monday, under the presidency of Major S. Flood Page, when the following resolutions, which were passed at the extraordinary general meeting of the members of the Company held on the 11th ult., were submitted for confirmation as special resolutions, viz. :—

1. "That it is expedient to effect an amalgamation of this Company with the Australasian Electric Light, Power, and Storage Company (Limited), and that with a view thereto this Company be wound up voluntarily."

2. "That Samuel Flood Page and James Drayson Austen Norris be and they are hereby appointed liquidators of the Company for the purpose of winding up its affairs and distributing the property"

3. "That the remuneration of the liquidators be £210, to be divided between them in such proportions as they shall think fit."

4. "That the Company do hereby approve and ratify the Conditional Agreement, dated the 20th day of May, 1886, made between the Company of the first part, Thomas Alva Edison of the second part, and the Australasian Electric Light, Power, and Storage Company (Limited), of the third part, which has been submitted to this meeting, and that the liquidators be and they are hereby authorised to adopt the said agreement, and carry the same into effect, with or without modification as may be mutually agreed upon."

5. "That the fully paid ordinary and deferred shares respectively of the Australasian Electric Light, Power, and Storage Company (Limited), coming to the hands of the liquidators, under the provisions of the said Conditional Agreement, shall be applicable in the winding up of this Company for the purpose of distribution amongst the members thereof, ratably in proportion to the number of their fully paid 'A' shares in this Company, one of the said fully paid ordinary shares, and one of the said fully paid deferred shares of the Australasian Electric Light, Power, and Storage Company (Limited) being given in exchange for one fully paid 'A' share of this Company."

The SECRETARY (Mr. J. D. A. Norris) read the notice convening the meeting as above.

The CHAIRMAN proposed the confirmation of the resolutions, and in the course of his remarks stated that all the shareholders of the Company, except one—who was not in England, and who could not be got at—had expressed cordial approval of the arrangement. Lord Tweeddale had also been good enough, at some inconvenience, to attend the meeting that day, in order to show his approval of it. He himself felt that there was some hope of their being able to do some business in Australia under the new order of things. He then read the resolutions, as above.

In answer to Mr. MOUNT,

The CHAIRMAN explained what was done at the last meeting. He stated, in further reply, that since Mr. Verity's letter was written, Lord Tweeddale and Sir V. Barrington had seen Mr. Verity, who had stated that he would not have issued the letter if he had known what he had been told afterwards. Mr. Verity also withdrew the letter.

Lord TWEEDDALE supported the statement regarding Mr. Verity's withdrawal of his opposition to the arrangement. He believed that Mr. Verity was entirely satisfied. Personally, he congratulated the shareholders and the Directors on having brought the arrangement to a head, and he believed there would now be a good prospect for the Company.

The resolutions were seconded and confirmed.

On the motion of Lord TWEEDDALE, seconded by Mr. PURMAN, a vote of thanks was passed to the Chairman, and the proceedings then terminated.

United Telephone Company (Limited).

Report of the Directors for the year ending 30th April last, to be presented to the shareholders at the sixth annual ordinary general meeting of the Company to be held at the City Terminus Hotel, Cannon-street, London, on Tuesday, the 6th inst., at 2 o'clock p.m. A reference to the capital account will show that up to the 30th April, 1886, the sum of £186,666. 14s. has been expended upon the works in connection with the metropolitan district and instruments on royalty in the metropolitan district and subsidiary companies, being £25,799. 18s. 8d. more than the outlay shown in the last balance-sheet. The revenue accounts show that the receipts of the Company from all sources properly attributable to the year have been £122,283. 15s. 1d., as against £103,000. 8s. 4d. in the preceding year, or an increase of £19,283. 6s. 9d., and the expenditure has been £54,681. 6s. 1d., as against £46,408. 6s. 1d., or an increase of £8,273. The working expenses for the year in the metropolitan district have been £32,548. 4s. 8d., as against £30,172. 19s. 7d. for the preceding year, or an increase of £2,375. 5s. 1d. The balance of net revenue account is £70,276. 17s. 3d., of which amount the sum of £17,711. 19s. 7d. has been absorbed by the payment of an interim dividend at the rate of 8 per cent. per annum for the first half year ending 31st October, 1885, and the directors recommend a further dividend of 9s. per fully paid £5 share (part paid shares receiving in proportion) for the second half year ending 30th April, 1886, amounting to £40,279. 19s., making a total dividend of 13 per cent. for the year. The directors also propose to carry £10,000 to reserve, leaving a balance of £2,284. 18s. 8d. to be carried forward. A sum of £2,753. 9s. 11d., representing profits derived from exceptional sources, has been carried direct to the reserve fund, in addition to the amount set aside for depreciation. The directors have, subject to confirmation by the shareholders, elected Mr. E. Dwyer Gray, M.P., to a seat on the Board. The shareholders will be asked at the general meeting to confirm the appointment. Mr. Dillwyn Parrish and Mr. W. Cuthbert Quilter, M.P., retire by rotation, and, being eligible, offer themselves for re-election. The auditors, Messrs. Quilter, Ball, and Co., and Messrs. Price, Waterhouse, and Co., also retire.

BUSINESS NOTICE.—Messrs. Henry F. Joel and Co. have removed from Tower-chambers to more commodious premises at 31, Wilson-street, Finsbury, where they will carry on the business of manufacturers of electric light apparatus and contractors.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. JUNE 30.		BUSINESS DONE WEEK ENDING JUNE 30. Highest.		Lowest.
Anglo-American	32,	33	32½		32½
Do. Preferred	54,	55	54½		—
Do. Deferred	10⅞,	11½	11½		—
Brazilian Submarine	10½,	10⅝	10⅝		10⅝
Cuba	10½,	10⅝	10⅝		—
Do. Preference	18½,	19½	—		—
Direct Spanish	1½,	2	—		—
Do. Preference	9,	10	9½		—
Direct United States Cable	9,	9½	9½		—
Eastern Telegraph	10⅞,	11	11		10 11-16
Do. 6 per Cent. Preference	14½,	14⅝	14 7-16		14⅜
Do. 5 per Cent. Debentures, 1899	105,	108	—		—
Eastern Extension	12½,	12⅝	12½		12½
German Union	9½,	9⅞	—		—
Globe Telegraph and Trust	6½,	6⅞	6⅞		6½
Do. Preference	13½,	13⅞	13⅞		13⅛
Great Northern	12½,	12⅞	12 11-16		12⅝
Indo-European	34½,	35½	35½		—
Reuter's	6,	6½	—		—
Submarine	200,	210	208		205
West India and Panama	½,	¾	9-16		—
Do. 1st Preference	8,	8½	—		—
Western Brazilian	7⅛,	7⅜	—		—
Western Union 7 per Cent. 1st Mortgage	118,	122	—		—
Do. 6 per Cent. Sterling Bonds	103,	107	—		—

TELEPHONES.

Consolid. Telephone and Maintenance	13-16	15-16	⅞		13-16
Oriental	3-16	5-16	—		—
United Telephone	14½,	14⅝	14⅝		13 11-16

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	2,	2½	2 7-16		2⅜
Do. (fully paid)	4,	4½	4 7-16		4⅜
Swan	1⅜,	1⅝	—		—
Maxim-Weston	3-16	5-16	—		—

MISCELLANEOUS.

Telegra Construction	40	41	40⅜		39½
India Rubber, Gutta Percha, and Telegraph Works	22½	23½	23½		23⅛

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NOTES.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 2nd inst. amounted to £2,889.

GUNMETAL VERSUS IRON WIRES.—The French Minister of Posts and Telegraphs has ordered gunmetal wires to be substituted for iron on some telegraph lines.

ELECTRIC SIGNAL BALLOONS.—Mr. Eric Bruce's balloons, with incandescent lamp inside, for military signalling at night, are to be tried by the French Government.

DIRECT SPANISH TELEGRAPH COMPANY.—The estimated traffic receipts for the month of June were £1,513, against £1,343 in the corresponding period of last year.

LONG DISTANCE TELEPHONY IN AUSTRIA. — Telephonic communication has been effected between Vienna and Brünn, a distance of 150 kilometres, or about 100 miles.

EASTERN TELEGRAPH COMPANY.—The traffic receipts of this company for the month of June amounted to £45,100, and to £41,514 in the corresponding period of 1885.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY.—The traffic receipts of this company for the month of June amounted to £38,894, and to £37,846 in the corresponding period of 1885, showing an increase of £1,048.

MR. GORDON'S TREATISE ON ELECTRIC LIGHTING.—We are informed that Messrs. Gauthier, Villans and Co., of Paris, are bringing out a French translation of Mr. Gordon's book on electric lighting.

ELECTRICITY IN SCHOOL.—The subject of the theme set the pupils of the Ecole Centrale for the end of the scholastic year is "The utilisation of a waterfall, equal to 300 h.-p., for the public and private lighting of a town."

COLONIAL TELEGRAPHS.—To-day a paper will be read at the Indian and Colonial Exhibition, on the subject of Colonial Telegraphs, by Mr. James Sivewright, C.M.G., a report of which will appear in our next week's number.

LIGHTING IN PARIS.—The new Military Club, at the corner of the Place de l'Opéra and the Avenue de l'Opéra, which was lighted, at its opening, by Edison lamps, maintained by storage batteries, is to be permanently lighted by electricity.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 2nd July, were £2,266, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

GREAT NORTHERN TELEGRAPH COMPANY.—The receipts of this company in June were £23,600, and the receipts for the period of January to the 30th June, £124,560; for the corresponding months in 1885 and 1884 to £142,840 and £129,520 respectively.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended the 30th June are £2,862, as compared with £2,895 in the corresponding period of 1885. The March receipts, estimated at £5,959, realised £6,193.

DOMESTIC ELECTRIC LIGHTING.—The Electrical Power Storage Company have successfully started an installation of the electric light at the residence of Mr. J. Goddard, of Leicester. A 3½-horse gas engine drives a 3 unit dynamo, the total number of lamps fixed being 85.

TRANSMISSION OF POWER.—The Marquis Luigi Fonti has conceived a new method for the transmission of power, consisting essentially of decomposing water by the current of a dynamo, driven by hydraulic power, and transmitting the gas by the conductor to gasometers at the receiving station.

CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this company during the month of June was 3,376, estimated to produce £2,775, against 3,715 messages, producing £3,032 in the corresponding month of last year. The traffic receipts for the month of March, estimated at £3,300, realised £3,345.

THE TELEPHONE IN ITALY.—The Italian Government, recognising the necessity for bringing up the telephone service to the requirements of the country, has appointed a Commission, which met for the first time on 16th June, and decided to consult the Chamber of Commerce, the Municipalities, and the existing telephone *concessionnaires* in the kingdom.

BLACKBURN TOWN COUNCIL AND THE TELEPHONE.—At a recent meeting of the Blackburn Town Council a resolution was passed accepting the offer of the Lancashire and Cheshire Telephone Exchange Company (Limited), to connect the Bowland works with the local municipal exchange by telephone, at a rental of £65 per annum for a term of five years.

THE NON-DESTRUCTION OF FILAMENTS.—Messrs. Siemens Brothers have lately been making lamps filled with hydrogen, and they find that these lamps do not become sooty on the inner surface of the glass. Next to a filament which will remain incandescent in the open air an envelope which will remain clean and not of itself destroy the filament is a desideratum.

SCHOOL OF TELEGRAPHY.—We notice that some interest is being taken on the Continent in the method adopted in England for teaching what we may term applied electricity. An article has appeared in our Italian contemporary, *L'Elettricita*, describing the school in Princes-street, now under the management of Mr. W. Lant-Carpenter. This is, we believe, at once the oldest and the most flourishing of our private schools.

LIGHTING AT MONACO.—The lighting installation at the Ministry for War, Monaco, put down by Schuckert, of Nuremburg, comprises 600 Edison lamps of 16 candle-power, though only about 400 are likely to be required at the same time. The current is supplied by two compound Schuckert dynamos, one for a hundred and fifty and the other for two hundred and fifty 16-candle lamps, the respective speed being 780 and 670 revolutions per minute.

RATIONAL SPEAKING TUBES.—An improvement, suggested by the telephone, has been made in the old speaking tube, by introducing a fork or branch, one end of which receives the flexible tube carried to the ear, while the other terminates in a bell mouth for speaking into, thus preventing the necessity of transferring the end of the tube from mouth to ear, and *vice versâ*. This is called the Pontifex speaking tube, and it is made by the Electric Apparatus Company.

A FAR FETCHED IDEA.—The *New York Herald* gives prominence to a scheme of Mr. Cloudman for lighting the Atlantic ocean by ten stations, anchored in the bottom of the sea, along the European-American route. The ends to be served by this bold conception would be to make meteorological observations, to communicate with ships, to signal, to help distressed vessels, and to give storm warnings. Of course, the electric light would be employed, each station being provided with its characteristic light.

ELECTRIC LAUNCHES.—The Electrical Power Storage Company have recently completed another electric launch, which

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was tested last Saturday on the Thames. It was arranged that the Duke of Bedford's launch should be run at the same time, and the two electric launches started from Kew Bridge up to Teddington, and thence back to Millwall, causing considerable sensation. The Duke and Duchess of Bedford and others were present at the trial, which was most successful throughout, and more than answered the expectation of the builders with regard to speed.

ELECTRICITY FOR THE HEALING ART.—The Electric Apparatus Company have brought out a new induction coil actuated by a bichromate battery, and self-contained in a small box; and also a new constant-current battery, with means for regulating the intensity of the current from one cell to another, so that the force is increased progressively without the patient perceiving it. Moreover, in no form of battery for cauterisation do the details appear to be so well worked out as in the Byng cautery battery taken up by this firm, because they found no other for the purpose that they could recommend.

AN ELECTRIC PROBLEM.—Has the question of the simple or consequent poles of dynamos been sufficiently considered and discussed? In the earliest form of electric generator simple poles were used, viz., one N, and the other S; but in the machines which prevail at the present day, the N and the S are each made by two or more coil magnets, resulting, of course, in consequent poles; that is, two making N and two S. In the first case there may be lines of force running to waste; in the second there may be eddy currents and lines of force contending with one another. Which is best?

RYDE ELECTRIC RAILWAY.—A few days since the annual meeting was held of the Ryde Pier Company, Isle of Wight, when the directors reported to their fellow shareholders that the Ryde Electric Railway had been completed and put into operation at an entire cost of £1,300. The experience so far acquired in regard to the new line is in every respect satisfactory, and the management stated that the increase of the traffic, and the small proportion borne by the working expenses to the gross receipts, justified them in congratulating the proprietors on the wisdom of their decision in adopting this mode of locomotion.

NEW WIRE TESTER.—A wire tester, specially designed by Mr. W. H. Bailey, has been constructed by Messrs. W. H. Bailey and Co., of the Albion Works, Salford, for the use of the South Australian Government Telegraph Department. The tensile strength of the wire is tested in an ingenious manner by means of a column of mercury, and when the wire breaks a back-pressure valve prevents the return of the mercury, so that the breaking strength of the wire is thus exactly indicated. There is also a diagram attachment used with the machine which indicates on metallic paper the elongation of the wire before the maximum breaking strain of the wire is reached. The arrangements of the machine are so simple that levers and springs are entirely dispensed with.

THE TELEPHONE IN FRANCE.—M. Granet, French Minister of Posts and Telegraphs, has formed a project for reorganising the telephone service of his country. According to the *Journal des Débats*, a company is to buy up, on account of the State, the lines temporarily conceded to the Societé Générale des Téléphones, which is to work for thirty-five years without any guarantee of interest, while it is to lay telephone lines wherever they are required. The yearly subscription is to be 400fr. (£16) for Paris, and 300fr. (£12) for the departments. The capital is to be 25,000,000fr., or £1,000,000, with power to raise three times the amount by debentures. At the expiration of the concession the lines will become the property of the State, which also reserves to itself 15 per cent. of the profits.

THE INDIAN TELEGRAPH DEPARTMENT.—A Government resolution, published in the Indian *Gazette* of June 26th, conveys the thanks of the Governor-General to the Telegraph Department, in connection with the advance into and the occupation of Upper Burmah; and it is a pleasure to note that appreciation is expressed of the excellent services rendered in circumstances of much difficulty and danger by this department. The Governor-General eulogises the ready devotion to duty displayed in cheerfully accepting the hardships and risks involved in operations with an army in the field. The foresight and ability displayed by the Director-General are specially mentioned, and the Governor-General in Council gives cordial thanks to Mr. Cappel, Director-General; Mr. Brooke, Director of Construction, and several other officers of the department.

"INDUSTRIES."—This is the title of a new paper, with central offices at Manchester. We believe the proprietors are going to make a bold bid to achieve the impossible. The late Lord Brougham went in strongly for a "little of everything," but he also added "everything of one thing." The new paper has, or is to have, a little of everything; but it is not to have a "speciality." A second weak feature is the giving of "prizes." Surely the best way to make a paper successful is to make it worth the purchase money. Adventitious aids of the "prize" character savour too much of *Tit Bits* and that class of literary work. The first number is well printed upon good paper, and contains some articles interesting to electricians. Of these we may mention one on the principles of "Secondary Battery Construction," and another on "Telegraphy in Japan."

A YANKEE DODGE EXPOSED.—A report comes from Boston that a gross telegraphic swindle has just been exposed. It appears that a certain syndicate, calling itself "The American Telegraphic Company," of 90, Washington-street, advertised situations to young men and women, in which from 45 to 125 dollars a month could be earned. Of course, like all similar advertising frauds the applicants had to pay so much in advance. A large number who had paid from 10 to 45 dollars, finding that there was no prospect of getting the promised situation, but were kept in suspense for weeks, combined and caused the head of the concern—one Hellehan—to be arrested for obtaining money under false pretences. It is not yet ascertained what punishment has been meted out to this enterprising gentleman, but it is to be hoped that both he and his confederates will receive a smart sentence.

ELECTRIC LIGHTING AS AN INVESTMENT.—With a view to put at rest the question whether electric lighting constitutes a profitable investment, the *Scientific American* lately addressed a circular to the general managers of a number of such companies, asking for their experience, especially directing their inquiries to those adopting the Thomson-Houston system. The general tenor of the replies is that many of the local companies are earning better dividends than are yielded by the majority of other new enterprises, the question of profit resting first with the locality and then with the system employed and the ability displayed in the management. The highest returns came from Omaha, Nebraska, where a company, operating four 30-light dynamos, had earned at the end of the first three months after incorporation 4½ per cent. on the investment, or at the rate of 18 per cent. per annum; and two more dynamos of the same capacity have since been added to their plant.

LIGHTING AT THE COLINDERIES.—The four 50-unit Elwell-Parker dynamos, driven by two compound Galloway engines,

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each giving out 80 horse-power on the brake, maintain 11,800 incandescent lamps, chiefly Swan, for the most part of 5 candle-power, but including some of 10 and 20 candles. Though these lamps might be maintained by three dynamos only, all four are used, and there is no duplication, nor any storage batteries; yet there has been no failure or hitch of any kind. The Pilsen, Crompton, and Brush arc lamps, maintained by their respective dynamos, driven by the Davey-Paxman engines, already illustrated and described in *The Electrician*, have spare machines to fall back upon; but there is no general duplication. Yet there has been no extinction, and no serious mishap or accident, for the men, under the superintendence of Mr. Schultz, are all trained to their work, and have been engaged on it for two or three years. The happiest effect is produced by small red and green incandescent lamps hidden in the vases of flowering plants.

Silvering Glass.—The incidental remarks in popular books often tend to show the wide applicability of an art, and to indicate directions in which students of pure and applied science may work with advantage. How many of those who study electricity realise the precautions that have to be taken in various industries against its action? In some cases it is turned to good use, in others it proves a trouble. In the "Pictorial History of Lancashire," p. 98, is a short popular description of a method for silvering glass, wherein is the following reference to electricity:—"So long as the amalgam is in an imperfect state, portions of it are liable to be detached from it by any electrical charges in the atmosphere or violent concussions of the air, such as a thunderstorm, a very high wind, or the firing of artillery." An accident so caused means generally the doing of the whole work over again. It would be interesting to know if any attempt had ever been made to utilise electricity to aid in the silvering or tinning of glass, instead of considering it in the light of something to be avoided.

Chesterfield and Midland Counties Institution of Engineers.—At the annual general meeting of the members of this institution, held in Chesterfield on Saturday week, Mr. G. E. Smith, electrician, Nottingham, exhibited a patent safety electric miners' lamp, weighing 7lb., and said by Mr. Schanschieff, the inventor and patentee, to be capable of giving light continuously for seven hours. The light is an incandescent lamp of 3 candle-power. For the use of miners, and in other cases where necessary, the batteries are hermetically sealed. The peculiar simplicity of the ordinary cell extends to the hermetic cell also, which is recharged without any screwing or complicated manipulation, and in a very short space of time. The lamp exhibited had been carried about the workings in Annesley Colliery, where safety lamps were used, and was perfectly safe in gas. In answer to inquiry, Mr. Smith said the makers asked £2. 10s. for the lamp, but he thought the price would be brought down to half that amount. The fluid was 2s. per gallon, and the cost of each recharging of the lamp would be 6d.

Thermo-Electric Couples.—An abstract of a paper by G. H. Le Chatelier appears in the current number of the Chemical Society's *Journal* as follows:—Avenarius and Tait have shown that the electromotive force of a metallic couple increases between 0° and 400°, in accordance with a parabolic function of the absolute temperatures of the two junctions, $E = A(T_1 - T_0) + B(T_1^2 - T_0^2)$, or if one of the two junctions is kept in melting ice, $E = at + bt^2$, where t is the ordinary temperature of the warm junction, and a and b are constants depending on the nature of the couple. The author finds that this law holds good for temperatures above 400° up to a certain limit which depends on the nature of the couple, and beyond which the value of the coefficients suddenly changes, whilst the nature of the equation remains the same. Values of the coefficients for platinum and platinum-iridium at different temperatures are given in the original paper. The calculated results agree well with those actually obtained, and any divergencies may be attributed to the well-known irregularities of thermo-electric couples.

Testing Mercury Ores.—The *Journal de Pharmacie et de Chimie* gives two methods for testing mercury ores invented by Señor Luis de la Escosura, chief of the staff of the Spanish mines. The second and more simple of these is the following: The mineral, finely powdered, is placed in a platinum capsule in a mixture of water, hydrochloric acid and sulphite of ammonia. For a mineral with 10 per cent. of mercury the following proportions are adopted:—Mineral 200 grams, NCl. 10 c.c.m., water 90 c.c.m., sulphite 20 c.c.m., so that about 120 c.c.m. are obtained. These proportions ought to be modified according to the richness of the mineral. The platinum capsule is placed on a support, and a gold disc is plunged into it, soldered to a gold stalk which communicates with the zinc pole of a battery of a few elements. The capsule is connected with the other pole. At the end of twenty-four hours the operation is ended, the mercury precipitates itself on to the gold disc, the increase in the weight of which indicates the richness of the mineral. This simple process is, it appears, of rigorous exactness even for very poor ores containing less than one per cent. of mercury. The impurities which usually accompany mercury minerals do not interfere with the operation. This process, which has been employed at Almaden for about a year, has been found superior to all others.

Combination of Cadmium and Iodine.—Mr. A. P. Laurie, in a paper before the Chemical Society on "The Electromotive Forces developed during the combination of Cadmium and Iodine in Presence of Water," says he has determined, by means of a Thomson electrometer, the electromotive forces of cells consisting of a cadmium and a platinum plate immersed in a solution of cadmium iodide containing free iodine. In one set of experiments, the amount of cadmium iodide in solution was constant and the amount of iodine was varied; in another the amount of cadmium iodide varied, the solution being in each case saturated with iodine; in a third, a constant amount of iodine, but varying amounts of cadmium iodide, were used. The result of the experiments is to show that, if cadmium and water containing cadmium iodide and free iodine are brought together, a considerable electromotive force is developed, which steadily falls. This depends on the facts (1) that as the free iodine is diminished, the electromotive force falls gradually at first, but more rapidly the less iodine there is present; (2) that as the cadmium iodide solution increases in strength, the electromotive force falls very rapidly while very small quantities of the salt are present, but more and more slowly as the amount of salt present becomes considerable. In both cases the change may be represented by a continuous curve. The actual values are given in the paper.

Pressure on the Resistance of Electrolytes.—According to the Chemical Society's *Journal*, M. Fink, in a paper on the influence of pressure on the resistance of electrolytes, concludes: "That the researches of Colladon and Sturm, and of Herring have shown that the resistance of electrolytes is practically unaltered by increase of pressure, whilst the more recent experiments of Lenz indicate a decrease of 0·02 per cent. in resistance for every increase of one atmosphere pressure, a result which would be a probable deduction from the experiments of Röntgen and Warburg on the influence of

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pressure on the specific viscosity of liquids. The results are here given of experiments with solutions of hydrochloric acid, sodium chloride, and zinc sulphate, of various degrees of concentration, compressed at various pressures up to 500 atmospheres by means of a Cailletet pump. The apparatus is described in detail. The principal results are as follows :—(i) The resistances of the above electrolytes decrease proportionally with the increase of pressure up to 300 atmospheres; at higher pressures the relative increase is somewhat diminished, although it is allowed that this result may be due to errors in the manometer; the numerical results are practically in accordance with those of Lenz, although they are somewhat modified by changes in other conditions, such as temperature, concentration of solution, and nature of the substance dissolved. (ii) It is shown by application of the formula $p=\frac{\Delta v}{\mu}$, in which p is the pressure and μ the coefficient of compressibility of a solution, that the change of resistance in a liquid by warming under atmospheric pressure is not conditioned by change of density, but by increase of molecular mobility."

TELEMAREGRAPHS.—The abstract of a paper by J. Troost, given in the Inst. of Civil Engineers' *Journal*, says that fifteen stations have been fitted up for tidal observations along the Scheldt and its tributaries, between Ghent and Lillo, and connected with a central registering station by four telegraphic wires. Each station is provided with a tidal indicator and an observer. The tidal indicator has a pulley, which is turned by the movement of a counterpoise float suspended from a cord wound round the pulley. A pinion on the axle of the pulley works in a segmental ratchet, turning on another axle, and thus imparts to it the motion of the float. The ratchet sector carries a pointer, turning on the same axle, and whose extremity travels along a concentric scale, and indicates the position of the float above a given datum. Another smaller sector is fastened on the same axle, and its motion is accordingly proportional to the motion of the float. This sector is in contact with the observer, and by aid of this ingenious apparatus, which is fully described in the article, it is enabled to transmit an electric current to the central station during a period proportionate to the distance it has turned from its initial position. The duration of the current, and consequently the height of the tide at the given time, is recorded at the registering station by a graver marking a horizontal line along a zinc plate on a vertical revolving cylinder. The graver is pressed against the plate during the passage of the current; and consequently the length of the line graven on the plate is proportionate to the height of the tide at the time. The observations are transmitted at intervals of five or ten minutes; and the graver descends a slight distance after each record, so that a series of equidistant parallel lines are marked on the plate, forming the ordinates of the tidal curve for the particular station. The records of four stations are successively registered by one instrument on the same plate, the greatest length of any line being less than a quarter of the circumference of the recording cylinder. If the variations in level were considerably less, one registering instrument would suffice for several stations. Copies of the records are printed off from the zinc plates.

PROVISIONAL ORDERS.—We have already dealt with the Chelsea provisional order, but a little more information is given in the following from *The Times* :—"A parliamentary return has been issued showing the applications to, and proceedings of the Board of Trade under the Electric Lighting Act, 1882. Applications for provisional orders were received by the Board of Trade on or before the 21st of December from the Chelsea Electricity Supply Company (Limited), and the West London Electric Lighting Company (Limited). The first of these orders was granted by the Board of Trade, and a Bill to confirm it was introduced into the House of Commons on the 11th of June, and will be proceeded with in the next session. In the second order the undertakers, besides the extension of area scheduled, sought power to extend for a period of one year the time within which the compulsory works were to be completed. This order was not proceeded with. Since the date of the last report a further extension of the time within which the deposit of capital should be made in the case of the Fulham District Electric Lighting Order, 1884, had been approved, but the period so extended expired on the 15th inst. Since the date of the last report the Board of Trade had received an application for a licence from the Dundalk Town Commissioners. This licence had been settled by the Board of Trade. The Board of Trade had also granted two licences, referred to in the last report—namely, one to the Dalton-in-Furness Local Board in respect of the district of the Board, and the other to Mr. J. E. Veale, in respect of the district of the St. Austell Local Board. After careful consideration, the Board of Trade had decided to insert in licences granted to local authorities provisions empowering the promoters, with the consent of the Board of Trade, to transfer all or any part of the powers, duties, and liabilities conferred or imposed upon them by the licence as to the whole or any part of the area comprised therein, to any other body or person, and provisions to this effect had been inserted in the Dundalk and the Dalton-in-Furness licences. In 1884 a licence was granted to the South-Eastern (Brush) Electric Light and Power Company (Limited) to light a specified area in the borough of Colchester. In August, 1885, the Company went into voluntary liquidation, but the Board of Trade had agreed to the transfer of the undertaking to the Colchester Electric Light and Power Company (Limited)."

TELEPHONY.—The following correspondence has appeared in *The Times* with regard to the recent decision discussed by us in our last week's issue. On July 6th Prof. S. P. Thompson writes: "In the columns of your Law Report of to day there occurs a most extraordinary instance of the evil tendency at present pervading the practice of even our highest Courts of warping or straining the language of a patent specification so as to make it read in some forced sense in favour of a patentee who is backed up by wealthy supporters. This evil tendency, which is deliberately fostered by eminent leading counsel and by a few professional experts, who lend themselves to this mode of securing a monopoly for the patentee, is rapidly bringing into discredit the administration of the patent laws. The present instance, which occurred in the Appeal Court in the case of the United Telephone Company *v.* Bassano, arose in the following way:—The defendants, who are a small provincial firm of telegraph engineers, had constructed a telephone transmitter in a manner which they honestly believed to be different, not only in design, principle, and mode of action, but even in the materials employed, from the transmitter invented by Edison, the American, whose patent is held by the plaintiff company. There had been some question whether the 'tension-regulator' or mechanism of the defendants' instrument was or was not substantially the same as that described in the Edison specification. Lord Justice Cotton, in giving judgment on this point, made the following statement:—'Edison had mentioned several sarts of tension-regulators, but in that which had been ultimately preferred there were fixed blocks and suspended pencils of carbon which acted by varying the tension according to the distance between the carbon

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points.' That is a very clear statement of what the learned judge considered the defendants to have infringed. But now comes the extraordinary fact that not only is this passage not quoted from the Edison specification, but there is absolutely nothing in the Edison specification even to support it. 'Fixed blocks and suspended pencils of carbon,' 'distance between the carbon-points,' are not suggested and never were suggested by Edison. The words 'fixed blocks' and 'suspended pencils' are never mentioned by Edison. Nay, even the substance 'carbon' is never once named by Edison. The nearest approach to all this in the Edison document is tufts of silk fibre covered with plumbago, or with volatilised metals, and lamp-black contained within a case. That a High Court of Justice can be so influenced by eminent advocates as to be able to warp and strain tufts of metallised silk and cases full of lamp-black into 'fixed blocks and suspended pencils of carbon,' and then to add that 'it was not the duty of the Court to point out the exact particular of the construction to which the infringement was due,' is one of those things which would be incredible if it had not actually occurred yesterday. But can any one explain how or why it is that not only in suits about telephones, but in suits about gas-engines and electric lights, the same process of judicial warping of patents has gone on?" And in reply Mr. John Imray writes:—"Under the heading 'Judicial Warping of Patents' Prof. Silvanus P. Thompson, in a letter published in your issue of this date, alleges that judges and justices of appeal are misled by counsel and expert witnesses to such an extent that they quite misunderstand patent specifications, and consequently give unjust judgments. The learned professor does not think it necessary to mention that he has himself condescended to perform the part of an expert witness, but as he has happened to be on the wrong side, *hinc illæ lachrymæ*. In the case referred to by Prof. Thompson, that of Edison's telephone patent, a new invention of an important and fundamental character had to be dealt with by the judges. It was not, like most patented inventions, a mere improvement in constructive details or in specific arrangements or combinations; it was an altogether novel departure, which, coupled with Bell's great invention, has led to a system of communication marvellous as it is useful. In such a case judges who know their duty do not tie down the invention to the precise details given by the inventor; they look for the principle on which the invention is based, they ascertain what is the spirit and essence, the 'pith and marrow,' of the invention, and if they see that, notwithstanding variations of form, material, or arrangements of parts, some rival apparatus has in fact the 'pith and marrow' of the original, they justly pronounce that to be an infringement."

City and Guilds of London Technical College.—The *conversazione* of the students of this college was held on Friday last, when a numerous company of their friends and relatives were invited to examine the numerous objects of scientific interest in the institution, as well as to participate in the pleasures of what in polite circles is called an "at home." A visit to this admirable institution—one of the few educational establishments in this country formed on the German principle of inculcating instruction in the applied sciences by means of practical experiment—always repays the visitor, but on the occasion in question it was made doubly attractive by reason of the fact that in addition to the ordinary mechanical, physical, and chemical appliances belonging to the college there were a great many exhibits kindly lent for the evening by a number of firms in the City and elsewhere. Messrs. R. and J. Beck and Mr. Crouch sent some highly magnifying microscopes, which were provided with some interesting object of the vegetable, the animal, or the mineral kingdom. Under each of these an incandescent lamp was placed, so that the guests might get a glimpse of a few of those wonders of creation which can only be revealed by these means. Mr. E. Cetti contributed a valuable collection of physical apparatus. The industries of soap and candle making were worthily represented by Messrs. Paton and Charles, John Knight, J. and C. Field, E. Cork and Co., each of whom sent a pretty case of their several specialities exhibiting the various stages of their manufacture. Messrs. Hopkins and Williams, Townsend and Mercer, Gaskill Deacon and Co., of Lancashire, Bevington, of Bermondsey, Pontifex and Wood, the Broxburn Oil Company, and Mr. Whitebread, of Chiswell-street, sent exhibits relating to chemical manufactures, with special reference to alkali, brewing, tanning, &c.; whilst the Express Dairy Company had a case showing the constituent elements of milk, &c. Electricity was represented by Messrs. Woodhouse and Rawson and the Electric Apparatus Company, who loaned a valuable assortment of their electrical appliances. But in this branch of science the college itself is for such an institution unusually well endowed. Indeed, it would be difficult to name an educational institute in or out of the United Kingdom where better means are provided for a thorough technical training in electrical science than the City and Guilds College, more especially in view of the fact that it has as its principal so eminent an authority as Prof. Silvanus Thompson. The weary student of text-books might well be excused for heaving a sigh of enviable regret as he walked through its spacious rooms, so fully equipped with all the requisite apparatus for gaining practically the knowledge which he is painfully labouring to acquire by the midnight oil. No better testimony to the advantages of technical education could be afforded than this section of the college presents. The whole of the building is lighted by incandescent and arc lamps of a variety of types, the currents being supplied by five dynamos of the Edison, Gramme, Victoria, Brush, and Phœnix designs. On Friday evening, it is unnecessary to say that, as on previous occasions of the same kind, the college put on something more than its everyday aspect. All the staircases and rooms were profusely decorated with flowers and bunting, some pretty effects in the former being produced in the water fountains by means of coloured glass and incandescent lamps. Amongst the more serious part of the night's proceedings was a lecture delivered by Prof. Thompson on the theory of the waves of light and polarised light. The lecturer, with the assistance of Mr. Kockburn, gave numerous illustrations of his subject by the electric light and the analyser. It is superfluous to add that the wonderful and beautiful alternations of colour thus displayed of that mysterious something which, in the words of the lecturer, "scientific men have agreed, for want of a better name, to call the ether of space," excited the greatest admiration and drew forth repeated rounds of applause. To this succeeded a short lecture on the nature and the component elements of the different classes of explosives, by Mr. John Castell-Evans, which was also very interesting. Whilst these gentlemen were discoursing learnedly on their different themes, a concert was being given in an adjoining chamber by the college choir, assisted by Miss Dickinson, Mrs. Montague Burnett, Mr. Aspinall, and Mr. F. M. Smith. Not the least interesting feature in connection with this part of the programme was the arrangement of a number of telephones by which the guests could hear the singing in a separate part of the building. In conclusion, we have only to add a word of congratulation to the students on the success which attended their painstaking efforts to provide for the comfort and entertainment of their guests.

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TELEGRAPH REFORM.

On Tuesday morning a Congress of the Chambers of Commerce of the British Empire was opened in the Indian and Colonial Exhibition. The President of the London Chamber of Commerce (Mr. J. H. Tritton) occupied the chair. Amongst the subjects that came up for consideration was that of postal and telegraphic reform. The Congress lasted for two days.

SIR JAMES ANDERSON read the following paper:

The London Chamber of Commerce having requested me to prepare a short paper upon Telegraphic Reform, for the purpose of opening a discussion at the present Congress, I have endeavoured, in the following observations, to comply with their request, taking the four points specified in their letter, viz. :—

1. Reduction of Rates,
2. Extension of System,
3. Government Supervision,
4. Neutralisation of Cables,

as those which appear to the Committee most deserving of consideration.

It will probably be found that if a satisfactory solution of the first point can be arranged, all the other points will naturally adjust themselves.

It is not claimed in this paper that any of the methods advanced as illustrations of what can be done are specially recommended, nor has the sanction of any of the Submarine Telegraph Companies been obtained for putting them forward as representing their views.

They are given with the object and hope that discussion may develop sooner or later some plan for reducing tariffs which will be satisfactory to the public, and not ruinous to the shareholders, who have risked so much capital to establish the existing system of submarine telegraphy, which has already united all the commercial points of the world.

As a first illustration of what could be done to meet all the four points referred to, and dealing only with round figures, the following statement is made:—

The capital invested in this enterprise up to date is about		£35,000,000
The total revenue is	3,250,000	
Expenses, including cost of repairs, about 35 per cent.	1,137,500	
Net revenue	2,112,500	
Deduct 2 per cent. upon the capital for reserve and renewals	700,000	
	1,412,500	
Guaranteed interest of 4 per cent. on the capital	1,400,000	
		12,500

The present reserve of all the companies is about 10 per cent. on the capital.

If, then, 4 per cent. were guaranteed by the states and colonies specially interested, it would be in their power to adjust tariffs so as to reduce those which seemed too high, and to raise those which are too low, so that no loss need accrue to the guaranteeing powers.

But the cry would no doubt be for further reductions, and it is easy to estimate that if all the tariffs which are considered high were reduced by one-half, and those which are at present ruinously low doubled, the amount required to make up the 4 per cent. would not much exceed £1,000,000 per annum to be divided amongst all the guaranteeing states.

Reducing the tariff as suggested would certainly give a substantial impulse to the development of telegraphy, and this would no doubt be followed by still further reductions, and the enormous increase of traffic which would result would in a few years provide a surplus for extensions which cannot now be carried out without state or colonial subsidies.

Several reasons readily suggest themselves which would justify Governments giving this guarantee, and running the risk of large reductions

Moderate reductions of tariff never give any great impulse to traffic, and private companies cannot incur the certain loss which reductions always involve otherwise than with extreme caution, and very gradually. It takes a considerable length of time to recoup such losses, and it may easily follow that by the time the revenue has recovered its former amount, opposition cables may be laid with the ultimate result of a combination to raise the tariffs to a point that will save the companies, with their unnecessary cables, from financial ruin.

If the states guaranteeing the 4 per cent. dividend were bold enough to reduce the tariff to a point below which it would not be necessary to go for many years, the enormous increase of traffic which would be developed would largely augment the growth of internal correspondence both by telegraph and post.

It would stimulate commercial activity, multiply transactions, and generally increase the wealth of the nations. Private companies cannot gain directly by these factors, but Governments gain in every particular, and gain at once.

Government can also effect economies by unity of management, absence of needless competition, and uniformity of an international system.

There is probably no system of inter-communication between nations so uniform as telegraphy—that is, the exchange of messages between two countries is, as a rule, about equal, and where this is not exactly the case, sufficient data exists to establish the respective proportions. So that the nations of the world could agree to deal with their receipts according to these proportions without rendering accounts.

This alone would effect a substantial economy, and is already done by a number of Continental states, and in my opinion it is in this direction and in that of low and uniform tariffs that we are progressing.

Another plan would be that, in consideration of a monopoly, Governments should regulate the tariffs, requiring a reserve for maintenance and renewals, and all excess of revenue over a given dividend to go in reduction of tariffs; but as there are companies which earn no dividend, this plan cannot be made so generally applicable, and I believe the experience with water and gas company monopolies has not made this system a favourite one.

Third Plan.—Germany, in the case of one company, has guaranteed a certain amount per annum, with the condition that a sum equal to 1 per cent. per annum of the capital be set aside for amortisation, and 10 per cent. of the revenue for repairs and maintenance, so that at the end of a given period the cable, together with the reserve, becomes the property of the Government.

They also retain the right to purchase at par any of the stock not cancelled by amortisation.

Fourth Plan, and this is a favourite proposition of Mr. Pender, the Chairman of the Eastern Telegraph Companies, who is absent upon his political contest. The Australian colonies at the present time have under consideration a proposal to guarantee to the Eastern Company and its partners and to the Eastern Extension Company the average revenue derived from Australian traffic over the last three years, and they may then reduce the tariff to what they please, subject to out payments to other Government administrations.

The colonies would thus take the risk of the increase, and if they are satisfied, as it is reasonable they should be, that a low tariff will give a great impulse to the traffic, then the amount payable under the guarantee will be comparatively small, and in any case the gain to the colonies commercially cannot fail to be very great. All the calculations on this point are now before the colonies interested. This plan is probably the simplest of all, requiring a minimum of negotiation, with the additional advantages of being immediately applicable and capable of being discontinued after an agreed period if found to be unsatisfactory. If adopted, it would probably, sooner than any other plan, lead to the adoption of a more general and extended international scheme.

It is obvious private companies cannot make sacrifices involving certain great loss, or if they must do so from undue competition, the benefit to the public will only be fitful, as either the companies must combine to raise the tariff or

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capital will avoid a class of property so uncertain in its durability, and unsafe owing to needless and ruinous rivalry.

Telegraph Reform.

Two or three sentences only need be devoted to this point.

The commercial public should be warned that, sooner or later, the present abuse of the code system will be stopped to the great inconvenience of those firms who are building up a huge mass of made-up words, syllabic combinations having the appearance of words only, and unknown to any language. This practice, which is growing, is *unfair*, if not illegal, and contrary to the convention by which all telegraph administrations are bound, and will some day have an abrupt ending, especially if ever there is Government control of any kind.

The system of coding really enables merchants to send on an average about ten words in one. The formidable-looking tariffs are, therefore, not so extreme as they appear, and the companies think they should be fairly dealt with.

As the general result of the last ten years' working with India, we are carrying four times the number of telegrams and making 44 per cent. more money; but one-third of this increase of revenue is due to other causes than the number of commercial messages.

We do not make any objection to a free use of all words not exceeding ten letters in the eight authorised languages, which provide at least 100,000 fairly good telegraph words, each word differing by two letters, and each of these 100,000 words can be arranged to express five different references, such as quantity, quality, freight, price, and time, as to any article which merchants are accustomed to deal in.

The system of manufactured words which some firms are persistently trying to force upon us enables merchants to tabulate a million of words, with practically unlimited power of expansion. This in time may drive us to a high single letter tariff, an authorised code or rigid restriction to what is meant by eight languages, and the attention of the companies has quite recently been authoritatively called to their duty of strictly observing the Convention rules.

The foregoing remarks contain, I think, plans by which reduction of rates and extension of the telegraph system can be provided out of revenue, and Government supervision will naturally be claimed by the guaranteeing states.

Neutralisation of Cables.

I now come to the question of the neutralisation of cables, what promoters of other submarine lines like to call alternate cables for a time of war.

To my mind this is not the main object for which submarine cables should be laid. There is a growing federation of commerce in which all nations are already free to share.

For all nations the "foreign trade of the world has become an extended home trade," and the two great factors which make the federation of our own race possible are steam and telegraphy.

These points have been already formulated by Mr. Crump, of *The Times*, and Prof. Seeley, of Oxford, and they will yet claim far more serious international attention than is now dreamt of.

As for submarine cables in time of war, it will be evident that if a number of Governments undertake to guarantee interest upon submarine cable property for the sake of controlling the tariffs, it will not be permissible for any one nation to damage or destroy them wilfully with impunity.

Already this question is becoming complicated. America, France, Germany, Italy, Spain, Greece, Turkey, Denmark, and England all own or have a direct pecuniary interest in cables.

Some of the most important of these Powers are making sacrifices and great efforts to extend their colonial system. Cable communication is indispensable to the government and defence of these colonies—to Great Britain and her colonies supremely so—and to all of them, as well as to every other country commercially, it is of the utmost value nowadays to have all parts of the earth in telegraphic communication, so that belligerents may by-and-bye be taught that they must fight their quarrels out without destroying the means of international intercourse which are indispensable to the commerce of those nations not concerned in the quarrel, and who are strong enough to make their wish not to be cut off from the commercial world respected.

All that, however, is only so far so good. The greatest deterrent to the destruction of telegraph cables in time of war will be the knowledge that there are so many routes by which a message can be sent with only a moderate delay that the breaking of a cable would not really affect a campaign or a single battle, and it would not therefore be worth while to destroy cables.

At present there are exceptions where this condition of various routes does not exist, and where it would not pay commercially to create more lines, but in the event of war in which Great Britain, for instance, might be involved, about three or four months would suffice for strategical cables to be laid to secure all the telegrapic communication necessary for a campaign in any given part of the world. Ten thousand miles of cable could be made and shipped in four months.

It should not be forgotten that prior to the outbreak of any war the cables which exist suffice for the arrangement of fleets and armies.

It is altogether improbable that all the cables would be destroyed before war was declared, then, in that event, with the foresight we have a right to expect, the fleet, despatch boats, armed cruisers, and colonial defences would be so arranged that, at all events, telegraphic communication should not be all we had to rely upon. *In any case, there is no alternative that can be suggested other than strategical cables to be laid when required.*

Until necessary such cables should not be laid. It would be a waste of money, and their position would be known, which need not be the case if they were not laid until they became indispensable.

The conditions which should govern the laying of all submarine cables, as far as they can possibly be observed, are the following :—

They should touch at as many points as are likely to develop traffic.

They should be laid in the track followed by the mercantile marine of the world, because, first, in the event of war the same cruisers which protected our commercial marine and our transports would so far protect the cables.

Second, if interrupted upon any section, the commercial steamers passing to and fro can bridge over the broken section by carrying telegrams; and one or more would be chartered for this purpose until repairs were effected; or gunboats could in time of war bridge over the short interrupted sections; and *there is no doubt that hereafter ships with telegraph cables will always follow the fleet*, with the object of connecting any point best calculated to insure uninterrupted communication with the base of operations or head-quarters. Cutting cables, therefore, in time of war is not so important as it looks.

Long cables of several thousands of miles should be avoided as far as possible. There are no commercial points of the first importance at the present time unsupplied with telegraphic communication.

Any extensions of long cables cannot be made to pay. They can be cut as easily as any other cable in time of war, and require much time and great expense to repair, *so that they afford no additional security as alternate routes in case of war.* It would be better to employ the subsidy necessary to the existence of such cables in increasing the number of shorter sections where desired, touching at the commercial ports of the world; and in reduction of tariffs.

Fourteen years ago when I read a paper upon this subject the whole capital of the submarine cable companies was £10,000,000. It is now £35,000,000, and will probably ere long be £45,000,000, so that all the time the Governments of the world postpone acquiring control of submarine cables the more difficult it will become, as nothing anyone may write or think will prevent promoters of this class of enterprise from pushing forward schemes for more cables upon one pretext or another. Especially if the Governments are prepared to delude themselves by supposing that long commercially-unremunerative cables can have anything to do with securing a permanent communication in time of war.

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Strategical cables for war purposes are one thing. Binding all the ends of the earth and every commercial point of the globe for the purpose of promoting trade is quite another affair, infinitely more worthy the consideration of the representatives of the chambers of commerce here assembled.

I believe these observations embrace all the points necessary to open up a full discussion of the international value of telegraphy.

SUBMARINE CABLE COMPANIES.

NAME OF COMPANY.	Capital.	Cable Mileage.	Revenue, including Subsidies.	Reserve and Sinking Fund.	Dividends % on Ordinary Capital.
	£		£	£	
Anglo-American	7,000,000	10,437	291,036	851,872	1¼ per c.
American Telegraph and Cable	2 860,000	5,537	116,000	†	5 ,, ‡
Black Sea	130,000	351	9,047	Nil.	4 ,,
Brazilian Submarine	1,450,000	7,496	158,485	45,466	6 ,,
Commercial Cable	1,600,000	6,600	225,000	?	?
Telegraphe de Paris a New York	1,680,000	3,409	64,000*	?	2 per c.
Central & South American	1,000,000	3,178	80,000*	?	?
Cuba Submarine	220i000	940	35,161	64,704	8½ per c.
Direct Spanish	238,379	1,175	18,780	9 800	Nil.
Direct United States	1,214,200	2,983	74,221	320,000	3 per c.
Eastern	5,747,100	19,207	672,358	444,875	6 ,,
Eastern and South African	950,000	4,554	134,095	109,265	6 ,,
Eastern Extension	3,401,900	12,821	506,493	616,945	7 ,,
German Norwegian	82,240	252	7,156	2,641	5 ,,
German Union	330,000	1,119	38,518	58,363	7 ,,
Great Northern	1,855,000	5,916	280,094	417,448	8 ,,
Hamburg Heligoland	10,500	32	589	260	4 ,,
London Platino-Brazilian.	483,480	1,058	12,180	9,268	1 ,,
Mexican	200,000	620	20,000*	?	†
Montevidean & Brazilian.	101,520	200	1,529	500	Nil.
River Plate	55,500	32	10,000*	?	?
Spanish National	237,190	2,135	25,000	?	Nil.
Submarine	338,225	803	131,577	180,465	14½ per c.
West India and Panama..	1,325,530	4,119	89,020	124,086	Nil.
Western and Brazilian	1,498,650	2,543	127,396	131,273	2½ per c.
West Coast of America	450,000	1,699	45,957	10,000	2½ ,,
	34,399,414	99,216	3,173,692	3,397,231	

*Accounts not obtainable. Revenue estimated. †No information published. ‡5 per cent. guaranteed by Western Union Company.

DISCUSSION.

The Marquess of TWEEDDALE then said :—Having been connected with the different submarine telegraph systems for many years past, I am very glad to have an opportunity of offering a few remarks on some of the subjects referred to in the paper which has just been read, a copy of which I have had the advantage of perusing. The first subject, namely, the reduction of rates, is the most interesting and the most important. Perhaps, at the outset, I may be allowed to point out that submarine telegraph cable rates differ in one essential point from postal and railway rates. A postal or railway rate is a fixed figure for so long as it remains unaltered by the authorities controlling the Post Office or the railway company. It cannot be evaded or modified by the public. This is not the case with submarine telegraph cable rates. When a submarine telegraph cable rate is fixed the code system comes into operation, and at once modifies the rate so fixed in a manner and to an extent which is not appreciated by the public. Sir James states in his paper that "the system of coding really enables a merchant" (and he might have added every individual) "to send on an average ten words for one paying word." Now, let me indicate what this means. It means that where a cable rate is fixed at, say, 9s. 4d. a word, the public, in fact, pay 11d. a word only. Nor has coding done its best, or shall I say its worst, in modifying rates. When Sir James first investigated this subject, he found that about seven words were sent for one paying word. This has been increased to ten, and there is every reason to suppose that the art of coding will be still further developed, so that more than even ten words will be sent for one paying word.

I may say, in passing, that I am not alluding to what Sir James describes as the unfair practice of using syllabic combinations in place of real words. It may be unfair, but it is impossible in practice to prevent it. My remarks apply to legitimate coding. I have shown that by coding the rate to Australia, though nominally 9s. 4d. a word, is reduced in practice to 11d. a word only. Now, let me point out what this rate comes to per 100 miles, and how it compares per 100 miles with land rates. Australia is 11,499 miles from our shores. The codification rate per word being 11d., the rate per 100 miles is ·094 on the actual rate, or ·94 of a 1d. on the published rate—*i.e.*, 9s. 4d. a word. The telegraph rate in Great Britain is ½d. a word, with a minimum of 6d. Taking 400 miles as the average distance traversed by a message in Great Britain, the rate per 100 miles is ·12, or half a farthing a word. Now, when it is borne in mind that a submarine telegraph cable costs five times as much as a land line, that its maintenance is infinitely more expensive, and that it is exposed to war risk, which must be provided for by a special fund, I think it will be admitted that the real rate at present in force between Great Britain and Australia is not only not an extravagant one, but is, in fact, a very reasonable one.

Another point to be borne in mind in discussing submarine telegraph rates is that the conditions and circumstances are not the same in respect to cables laid to the West or to America and to those laid to the East. In the former case there is no land competition possible. No monopoly (except in respect to landing at Newfoundland) is possible. In the latter case there is competition by land lines for a great part of the way to East Australia and China. And if there is no distinct monopoly, there is a quasi monopoly which cannot be overlooked. In the Atlantic the question of rates—*i.e*, the rate which is ultimately to prevail—is still an open one, and can and will only be decided by the operation of competition. Several rates have been tried, a 2s., a 1s. 8d., a 1s., and now the rate is at sixpence a word — reduced by coding to less than a penny a word. This rate has been in operation for a few weeks only. The increase has been so far about 110 per cent. This is not an increase sufficient to constitute it a paying rate, but it is sufficient, I think, to encourage the cable companies to persevere with it, so that the rate may have a fair trial. If the rate is kept at sixpence a word for a year, or even two years, the question of the rate which is ultimately to prevail will receive, I trust, a final solution.

In the case of the submarine telegraphs to the East, the conditions, as I have stated, are not the same. The question of rates, more especially in the instance of Australia, cannot be settled by competition by parties unaided by governmental contributions. The present rates are, I believe, only fair and reasonable, and here I may say that I entirely concur with Sir James's remarks as to the little value of moderate reductions in stimulating traffic, and the impossibility of companies incurring the risk of loss attending large reductions. Take the reductions made in this country from 1s. to 6d. The Government is losing 2d. on every message. This state of things would render any company bankrupt in a short time. There appear to be in the case of Australia, at any rate, only two modes by which a further substantial reduction of rates can be effected. One is by the method referred to in this paper, that by which the Eastern Extension Telegraph Company shall be guaranteed the average revenue derived from the Australian traffic during the last three years, the Australian Government being at liberty to reduce the tariff rate to what they please. The other plan is to largely subsidise a cable or cables from Australia to, say, British Columbia. One of those cables that, to use Sir James's words, "promoters of rival submarine lines like to call alternate cables for a time of war."

It is not for me to offer an opinion as to which proposal is likely to find favour with our Australian fellow subjects; but I should wish to point out that nothing, in my humble judgment, could be more unwise than to spend a large sum of money annually in supporting a cable or cables which could not possibly pay in time of peace, and the exact position of which would be known to all the Powers in time of war. Sir James has pointed out with unanswerable force that a truly alternative line for use and protection in time of war—a line laid for strategic purposes—should not be laid until war is imminent. For in that way only could it be laid with some prospects of its position being concealed from an enemy.

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On this subject of the protection of cables during a time of war I refer to the opinion of Admiral Sir Cooper Key, late First Sea Lord of the Admiralty. His opinion I understand to be that it will be idle to expect the Powers to agree to respect one particular class of private property, such as telegraph cables, rather than another during war. Consequently, the only way that we can hope to protect cables during war will be by means of swift armoured cruisers, which should be employed, not to convoy fleets of merchantmen, as of old, but to patrol the sea routes followed by merchantmen as well as by cables. It would be quite reasonable to expect the Admiralty to afford great if not complete protection to cables laid in the Red Sea between Aden and Bombay, between Madras and Singapore, and on to China and Australia, coinciding, as these routes do, with lines of commerce; but what protection could the Admiralty be expected to extend to a telegraph cable lying at the bottom of the sea for a distance of over eight thousand miles, altogether out of the way of the routes followed by merchant ships? The inference I should be inclined to draw from this reasoning is that if the Government of Australia are really anxious to bring about a large reduction of the telegraph rate, and are prepared to spend a considerable sum of money in rendering telegraphic communication not only more cheap but still more secure than it is, both in peace and in war, that money can be more usefully spent on the lines already existing than on cables to be laid in the Pacific, open to the serious objections of being laid at enormous depths and in long stretches.

In conclusion, I have only to say that I have not deemed it necessary to refer to that part of Sir James's paper which deals with the advantages likely to accrue from the submarine telegraph cables being taken over and transferred to the different Governments interested in them. It is an interesting matter for speculation, but scarcely within the range of practical politics. I will not occupy your time any longer, for I see more than one present able and, I hope, willing to take part in the discussion; but before sitting down I hope I may be allowed to express my regret at the absence of Mr. Pender, chairman of several telegraph companies, whose energy and success in promoting submarine telegraph enterprise is well known to many here present.

Mr. M'MILLAN (Chairman of Sydney Chamber of Commerce): Mr. Chairman and Gentlemen—We have two members of the meeting here connected directly with telegraphic work, Sir James Anderson and the Marquis of Tweeddale. This, of course, puts us to a certain extent in a somewhat delicate position, and I am sure that both Sir James Anderson and Lord Tweeddale will understand that in approaching this question, we must look at it from the point of view of our own interests. I think it may be considered an axiom that to further economy in the centre of the British Empire it is necessary to have greater telegraphic communication. Consequently, without meaning to emphasise my position as a representative from Australia, I think this matter of telegraphic communication is more urgent and of more moment in regard to Australia than any other part of the British Empire. I should like to clear away one misunderstanding in regard to one of the remarks in this paper of Sir James Anderson. I do not think that the movement in Australia towards having a separate cable was founded on any feeling inimical to those interests which already exist, but it was the result of what we could not help calling the very unneighbourly position taken up by the Indian Government. We found that the great drawback to the telegraphic system on our side was owing to the resistance of the Government to a reduction on the land lines, which we thought had been carried on by this country. Now, I had the honour to speak at a deputation where I interviewed the Postmaster-General of New South Wales, with regard to one of the schemes of Sir James Anderson's paper—that is to say, that the Australian colonies should make up any loss on any three previous years' working on the understanding that they would have the control of the rates. I may say that we have often suffered very much in the colonies from the want of a thoroughly commercial man at the head of the Post Office department. I am speaking now to commercial men, and while I do not wish to imply that a commercial man does not make as good a statesman as anyone else, yet I think if there is one department of the Government which requires a man of practical authority and business experience it is the postal department of the Government. This proposition was made, and I believe it received a great deal of favour at the hands of our Government, and steps were taken to get the other colonies of Australia to co-operate. I have another point to touch on, and that is the codification. I must say that I cannot myself see what limit could be put to the system of codification, and it would be very necessary, whatever may be the basis of future arrangements made, that if any arrangements were made between the Government and the colonies and the different telegraph lines, we should have a very clear understanding with regard to our position in this matter of codification. I may say that if there were stringent measures to narrow the codification it would practically do away with a great deal of the commercial use of the telegraphic communication a'together. You know the fact is, besides, that one of the greatest arguments for the reduction of charges is, in the first place, that by this codification you are liable to error, and, in the second place, as we all know, it unceasingly happens that, in order to avoid committing any errors, it is necessary to use the ordinary English language, and consequently this matter of cheap telegraphy is important from every point of view. I have no hesitation in saying that if the rates in Australia were reduced to a reasonable extent—if they were reduced to such an extent as to make the telegraphic code take the place of the ordinary letter or memorandum, so as to give us a chance of carrying out a large portion of our business operations through the telegraphic code—I was going to say if that reduction were made, I believe that so far as the Post Office Department is concerned the business would be doubled, if not quadrupled, so that, as a business transaction, they could not ultimately, as I urged upon our Government, lose upon it. I take it that we are met here to try and impress on the Government that it is of the utmost importance to thresh out this question.

Mr. J. K. BYTHELL, of the Bombay Chamber of Commerce, then said: Mr. Chairman and Gentlemen—I am sure that we are all greatly obliged to Sir James Anderson and the Marquis of Tweeddale for putting this question, from the companies' point of view, so clearly before us. When I got the list of subjects to be discussed at this conference I wrote to the Bombay Chambers of Commerce and asked them to give me their view on any question they wished me to refer to, and their opinion is that if the telegraph companies would make a reduction of 20 per cent., in their tariff it would be fully recouped by the increase of business that would assuredly follow that reduction. And in spite of the arguments laid before us by these two gentlemen, my own opinion is that if the companies did make a reduction, say of 20 per cent. in the rates to India, the revenue would soon be recouped by increased business. I agree with the last speaker in the remark he made that in spite of all our codes we are day by day obliged to telegraph literally to prevent mistakes. I may say as a matter of fact from my own experience, that we are very often deterred from communicating by telegraph simply because of the excessive cost. And I can speak from my personal experience, because the firm in which I am connected pay many thousands of pounds to the Eastern Company for telegraphy to India. With reference to the question of having a national guarantee, the question has come before us without any previous warning, and I do not feel that I am prepared to pass an opinion upon it. But I should like to take this opportunity of asking these gentlemen what they exactly mean by saying that some firms are having syllabic combinations of words which are unknown to any language. I thought that the rules of the last telegraph conference absolutely prohibited the making use of unknown words.

Sir JAMES ANDERSON said it was the abuse of consonant and vowel combinations making words unknown to any language that was complained of.

Mr. BYTHALL: We have only used Dr. Agar's books, which contain 150,000 words. We were not clever enough to do

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what Sir James Anderson has suggested, and I do not think that others should be allowed to take advantage of those who keep to the regulation code (applause). At the same time, I believe that it will be necessary to allow mercantile men to have their codes. (Sir James Anderson: Certainly.) I am sure if we had not an elaborate code for telegraphing the cost would be prohibitory. These are the only two points to which I wished to draw special attention. It appears to me that there is not much need of making any international convention. I feel impressed with the argument that such a convention would not be acted up to in time of war, and that by the means to which Sir James Anderson referred it would be very easy to keep our telegraphic communications open, even in time of war.

Sir WILLIAM ADAMSON, Singapore: Mr. Chairman and Gentlemen—I did not intend to speak on this question. We must remember that the two eminent gentlemen—Sir James Anderson and the noble marquis—have spoken entirely from their point of view. They are both well known to be connected with telegraphic companies, and their ability has enabled them to put their side of the case before us with considerable clearness and power. Now, I was very much surprised at the prominence which Sir James Anderson gave to the code question. It seemed to me that it was a warning to some of us that they proposed to make a change. If Sir James remembers my name he will connect it with a firm which has always used fair means of codification with the company. I think we have never used any of those compound words, and I claim that we have been using codes, and we are one of his best customers. I maintain that the proper use of codes is absolutely necessary. I say distinctly that if it were attempted either by the companies that exist or by the Government—supposing they were to take up the lines—if it were attempted to do away with the codes the trade of the world would be interrupted to that extent that there would be a public outcry. I do not know whether it is known to all of you, but I may say—and I speak for Bombay—for an active business connected with the East Indies the cost of telegraphy is a charge of about 6s. 6d. per cent. on an operation. You gentlemen from Australia, who deal in large lines, such as in wool, and in matters which you can express in two or three words, do not appreciate the number of articles that are sent from India and from the far East. Is is quite a common practice to buy to-day in Calcutta, Bombay, and Singapore 25 tons of goods, which may come to £800 or £900, and to sell them to-morrow in the London market, and that has to bear the expense of four telegraph words, do it as cheaply as you can. If we were interfered with as to this subject of codes, it would be made the occasion of such an outcry that even the Eastern Extension Company would not be able to stand against it. Sir James Anderson told us, and made an important point of the fact, and I was astounded that it was a fact that some firms were in the habit of using compound words. I was very much surprised to hear this, because by the law that you have laid down we are limited to English, and to the four Latin tongues, and to German, to which I think was added Dutch. Therefore, I cannot understand how the companies should allow anyone to use such words, or if they do they injure men like myself who are dealing fairly with the company on their own system. There are two points to which I wish to draw attention. In the first place, Sir James put before us a statement that the total capital account of the telegraphic cables of the world was thirty-five millions, and then he went on to say that 4 per cent. on that would be so much. Now, 4 per cent. is not a large return for telegraphic property. That may be conceded at once. But I think we may draw a distinction between the amount of money which has been sunk on the Atlantic cables and the amount of money which has been spent on the cables which stretch from here to Australia, and I think if he separated these two, and told us how much had been spent on the Eastern cables, perhaps, then, he would find himself with the present traffic able to make a much larger return than 4 per cent, and put a very much larger amount to the renewal fund. You must also remember that since those cables were made an enormous economical improvement has come about in that direction. A cable to-day does not cost anything like what it did ten years ago, and, therefore, that capital already sunk in the cables of the world is not worth its first value.

Sir JAMES ANDERSON asked leave to explain that neither he nor any one else connected with telegraphy that he knew of had any desire to put down the use of codes. In fact, the Companies were the originators of code language, and his friend Mr. Weaver, whom he saw sitting in front of him, was the first to introduce the word tariff, so that merchants could send only one, two, or three words if they thought proper.

The discussion was adjourned.

The discussion was resumed on Wednesday morning by Major P. B. WALKER, Superintendent of the Telegraph System of New South Wales. He said: Mr. Chairman and Gentlemen—I am much obliged to the members of the conference for permitting an adjournment of the discussion on Sir James Anderson's paper upon telegraphic reform, as it embraces such broad principles that the consideration of the many points enlarged upon must prove of the greatest interest, not only to commercial people of Great Britain, but to all parts of the world. Sir James Anderson seems to think that a satisfactory solution of the question of reduction of rates would lead to a natural adjustment of the other three points of telegraphic reform specified in his paper, and no doubt it would materially assist matters, though I fail to see how it can possibly affect the question of Government supervision. That is a point which must be dealt with upon its merits, leading as it does to a question involving the deepest consideration owing to the numerous conflicting interests which are at stake where so many Governments would be interested. And we have had recently an instance of the difficulties surrounding this particular feature of the question in the matter of reduced rates to Australasia, adopted by the Berlin Conference, but delayed by the action of the Indian Government, thus showing that the difficulty in connection with Government supervision is great.

The telegraphic companies have done much to promote commerce, have greatly enlarged general progress throughout the world, and certainly they are entitled to the most favourable view of their interests that can be given, because without such aid we should never have been able to utter those well-known lines, that

> London speaks at twelve o'clock,
> Australia reads ere noon the shock.
> Seems it not a feat sublime,
> Intellect hath conquered time.

We must assume that it is only just that the cable companies should ask a fair interest as a guarantee if tariffs are demanded that do not accord with their expenditure sufficiently to enable them to submit fair returns to their shareholders, as all cable property is of a risky nature, and although the capitalist may for years receive his dividends regularly, he stands a risk that no other investor does, viz., the risk of storm and tempest, rendering himself liable to rise some morning to find his properties swept away. It therefore necessarily follows that the companies must look out to protect themselves. Nevertheless, when the general public find that a sum of £300,000 per annum is being paid on Australian traffic for international telegrams alone, it is considered a striking proof that a necessity exists for cheaper communication with other parts of the globe, and the colonists naturally look for more popular rates than those now conceded. The ruling passion of the modern age in commerce is for cheap telegrams, and in a young country like Australasia, where telegrams can be sent in some of the colonies for a penny a word, and in others at 1s. for ten words and one penny each extra word, it presses hard for the colonists to have to pay 10s. 10d. per word (including the local rates) to the United Kingdom. Nearly 29 years ago, when first I joined the telegraphic service in the colonies, the charges were as high as six shillings for the minimum local rate and 9s. the intercolonial minimum rate, but it was found necessary to meet the demands of commercial enterprise and progress by bringing the most popular means of communication by telegraph within range of all classes.

Sir James points out that it would be prudent and proper for the Governments to give a guarantee; but if it be admitted

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(as pointed out by his paper) that reducing of the tariff, as suggested, would certainly give a substantial impulse to the development of telegraphy, and result in an enormous increase of traffic, I do not see why the companies do not in their own interests, and in the exercise of a commercial spirit, carry out these reductions. Experience has shown that other things have benefited financially, and made themselves popular institutions by adopting such a course, and perhaps the companies may yet see their way to assimilate their proposals to suit the public.

Sir James has suggested two ways of reducing the tariff, viz. :—

1. By a guarantee.
2. By a subsidy.

There is no doubt that a guarantee would be by far the best mode of dealing with the question asked, and leave the Governments interested free to deal with any further arrangements desirable for the public benefit by supplementing the means of communication, and although the traffic would be greatly augmented by a low tariff, still it would be necessary to regulate the guarantee upon the basis of the present traffic. I find that the traffic has for eleven years increased 40 per cent. per annum, and the last three years have shown a more moderate regular growth, which gives a sure basis for an estimate.

There is one other point in Sir James's paper having reference to the figures regarding the construction of cables which I cannot construe, owing to the absence of sufficient data. The cost is put down for expenses, including repairs, at 35 per cent., which appears to be a very heavy allowance, but I presume it is based on experience. The item of 2 per cent. for reserve and renewals also strikes me as heavy, especially as it can be reckoned that a reserve invested properly would recoup the principal in 20 years. Another reason which confirms my opinion that the proposed 2 per cent. for reserve and renewals is out of proportion to the necessities of the case is the fact that though the cables have been in existence for so long a time, the companies have only thought it necessary to make a reserve which at the present time aggregates 10 per cent. on the capital, and the company's judgment upon this point has been, I presume, borne out from the fact that they have hitherto sustained no serious loss.

Sir James Anderson points to the probability of codification messages being interfered with; but this would be a serious interference with the inter-exchange of mercantile as well as important Government and press messages. In addition to that, the companies themselves would suffer greatly, as although perhaps five or six words may be included in the code word, still it would lead to curtailment in the transmission of messages which, in the end, would cause a diminution in the traffic and loss to the companies. I would further remark that this system is also a great protection to the Governments and merchants in that it renders the secrecy of the messages inviolable. I know that difficulties have to be surmounted in dealing with this question, still the public convenience is one of the first principles of telegraphic reform, and to attempt to abolish the system of codification would be a retrograde step, disastrous alike to all classes of the community.

Sir JAMES ANDERSON, in reply, said: Mr. Chairman and Gentlemen—It would be very easy to prepare a paper to show that the Government save a great amount of money every year by having the use of the telegraphs in the matter of the concentration of our small forces in different parts of the world, and in the concentration of our fleet, as well as in moving them about from place to place. I have no doubt that is the great object they have in view when they talk of subsidies to the telegraph companies. It would, in fact, be easy to prove that they save much more money by the existing telegraphs than the amount that they give to us in subsidies. In my paper yesterday I tried to show that there were methods, if all the different countries of the world were combined, by which they could lower the tariffs very substantially. Major Walker just now says that if they admit that the traffic will grow largely they might very well show some public spirit and lower the tariff themselves. If, however, they were to lower the tariff, say, to 2s. to India and to 4s. to all other places beyond India, the companies would lose more than half their present revenue, and that would take possibly four or five years to recoup, and after that there would be no loss. But directors of companies are not allowed to take shareholders' money and run such risks. We are commercial companies, not philanthropists, and therefore you cannot expect us to do it. The loss of a million, however, divided amongst several Governments for two or three years, would be a very small loss indeed compared with the immense advantage of having cheap telegraphy. Probably no institution was ever devised more conducive to federation—just now so much talked about—than the making of telegraphy as cheap as possible to all parts of the world. I consider it is of far more importance than even cheap postage, because to be able to talk with the ends of the world in a few hours is a feature the vast importance and value of which has not yet been realised, and I do not think it is at all ridiculous on my part to show that there are methods by which this can be attained at a small risk and absolutely no loss to those giving the guarantee. If Government gave a guaranteed dividend, naturally they would want some supervision over the lines. Mr. Walker talked of the traffic increasing so much for eleven years, but he will be sorry to hear that it has fallen off very much now. There are cycles in the telegraph traffic of the world. Another of Mr. Walker's remarks was that the companies had not followed out the principles I had referred to of laying by a large reserve; but that has arisen from the fact that they are not all prosperous, and some of them, indeed, pay no dividend, and have no reserve to speak of.

A great deal has been said about the code. I beg to repeat it was the companies that introduced the code. I do not yield to any man in my enthusiasm for codification. When we were laying the first cable we talked about code language, and we have never faltered in our desire to have a good code. I have been for ten years the advocate of an authorised code, and at the last Conference the subject was passed by a large majority at two of the committees, but rejected by the full committee; and the reason why I advocated an authorised code was that we had many words that were very difficult and bewildering to our clerks, occupying four times as long to transmit as ordinary language. They were illegitimate words, which have given rise to a great deal of disagreeable correspondence and a good many meetings of the companies to try and suppress them. I have handed round the room a few prints with reference to these words which I happen to have at hand. I hope the meeting has no impression whatever that the companies desire to abolish code, or introduce anything other than what we would call a fair code. We have allowed eight languages, and we do not care whether you find 100,000 or 200,000 words in these languages, but I would like it to be established that there are certain books of reference to show that we are not being taken advantage of. I need not add anything more. I think, if my paper is carefully read, it will be seen that I have written with the view not of making any definite proposition, but of showing that there are plans for cheapening telegraphy, and it is most important for the interests of commerce and federation that this should be effected.

The CHAIRMAN then put the following resolution to the meeting, which was carried unanimously:—"That the reduction of the Anglo-Indian and Colonial postal and telegraph charges, and the neutralisation of cables, be commended to Her Majesty's Government and to the Governments of the various colonies as desirable in the interests of the Empire and of international commerce; and this Congress strongly urges Her Majesty's Government to advance such objects, when possible, by international treaty, and by inviting the joint action of the Colonial and Indian Governments thereon. In this view the Congress particularly points to the desirability of the assimilation of the Colonial and Indian postal tariffs to those of the minimum tariff of the International Postal Union."

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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SCIENCE AND ART.

The close relation which from the remotest antiquity has subsisted between Art and Science was agreeably brought into prominence the other evening, when one of the foremost branches of applied science assembled together in the splendid rooms of an Institute identified with the progress of that branch of pictorial art for which England is the most famous of modern nations. The conjunction was probably accidental, though the practical question relating to the preservation of water-colour drawings which the exhibition now on view is intended to solve may have had something to do with it; but one could not help being reminded of the fact that, although in the course of ages they have changed places in relative importance, Science and Art have never parted company, continuing as they ever have been, and probably ever must be, the one the helpmate of the other. The marked interest displayed by Prof. HUGHES'S friends in the rare pictorial show on the walls of the ROYAL INSTITUTE OF PAINTERS IN WATER COLOURS, marred only by the unfortunate absence of a catalogue, proved that the eye of Science is more appreciative and discriminating in matters of Art than its votaries are willing to acknowledge. It is rather the fashion for Art to depreciate Science; only the vulgarist of scientists ever run down Art.

Judged by the experience of history, these two great products of the higher human faculties always attain their supremest perfection at one and the same time, the period of greatest development in the fine arts being that of the most remarkable achievements of Science. Art only attained its modern stature with the help of Science; and Science has made most rapid growth when fostered by an age essentially artistic. The Renaissance was a scientific revival. LEONARDO and MICHAEL ANGELO were scientists by nature; the former boasted himself a master of almost all the sciences, and was certainly accomplished in some that had no apparent association with painting in oil. The greatest of living art critics prides himself on being a man of science, which if not an honour is at least a compliment to that field of intellectual labour in which he has won fewest laurels. It would be difficult to say precisely where a bias of mind in one direction or the other becomes a hindrance to the fullest development of powers; but it is certain that art has been known to degenerate into mechanism through too much science; whilst it would be hard to point to any scientific revival being degraded by over much imagination. For lack of it Science, as we may often witness, is but a lifeless machine; whereas, on the other hand, the scientists of greatest renown in ancient or modern times, have been men of vivid imagination and keenest insight, qualities which are strictly those of the poet and artist. Science is almost always a patron of the arts, and thus acknowledges the unconscious debt it owes them; and if the arts are a little shy of Science, it may in fairness be owned that their obligations are fewer and their apprehensions more just.

The occasion of the exhibition of old water colour drawings, to which members of the Society of Telegraph-Engineers were among the first visitors, seems to have been intended to demonstrate the permanency of that class of paintings, against the contrary assertion lately put about, to the alarm of everybody who possess water colour drawings of any value. The case against their permanency is fully stated by Mr. J. C. ROBINSON, in the *Nineteenth Century* for June, from which we extracted an interesting paragraph a fortnight ago. There can be no doubt that in sunlight water colours do fade; and our washerwomen would have told us the same without the help of a high-class magazine. The bleaching power of the sun over artificial colours is beyond dispute; just as is its power to give colour to the natural rose, whether on stems of summer garden or cheeks of healthy maiden. But there are evidently differences of colouring, both as regards method and medium, otherwise the majority of the pictures now exhibited on the walls of 191, Piccadilly would long ago have become mere shadows of their former glory, instead of being, as most of them really are, true and brilliant as if fresh from the painter's easel. A good many modern water colour drawings of priceless value have been ruined by exposure to daylight not directly in the sun's rays. On the other hand, a vast number of older paintings have survived exposure of all kinds, and remain to us apparently unimpaired. This is undeniable, whatever Mr. Robinson may argue to the contrary. Some of the newspapers, discussing the question, lay all the blame of fugitivity on the pigment; it would be just as safe to lay it on the paper. Pigments differ greatly in permanency; but so does the material on which they are imprinted, as every good housewife knows. The great art authority already referred to has always insisted on the importance of the drawing paper when the drawing is intended to survive; and has even recommended that the State should take upon itself the duty of manufacturing a standard paper of highest quality, duly stamped. Mr. RUSKIN knows what he is talking about, and we may conjecture that pigments wisely selected, on paper carefully manufactured, will stand any kind of light without serious detriment.

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As, however, we have to deal with pictures which are not always painted under these favourable conditions, and have to preserve them as best we may, the question raised by Mr ROBINSON as to the relative effect of sun light and electric light becomes interesting, and is one which we hope the scientist will, as he suggests, take up and solve conclusively. The incandescent lamp is most likely to give favourable results; and it would be well worth while to institute with that kind of lamp a series of experiments similar to that which Mr. ROBINSON has carried out with water colours exposed to the sun. It was almost a surprise, and quite a disappointment, that the *conversazione* last Tuesday week was not illuminated by electricity. But we cannot blame the ROYAL INSTITUTE OF PAINTERS IN WATER COLOURS for not trying an experiment with so rare a collection of paintings until some trustworthy data to go upon are forthcoming. The same thought probably occurred to the eminent electricians who inspected these pictures the other evening by the light of gas jets from the ceiling. The friendly relations between Science and Art could not be better exemplified just now than by discovering a sure means of preserving such works of art as are artistically strong but scientifically weak.

CORRESPONDENCE.

NERVOUS FORCE AND ELECTRICITY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As no opinions concerning my experiments appeared in your last issue, I now write to complete my narrative, and shall then subside. The nearest approach to my experiments that I have yet been able to find is one by Dubois Reymond, who found that a current was produced on the contraction of a muscle. I am not aware that he went beyond this. I explain how it is that the legs of a person whose spinal cord has been injured or severed are responsive to tickles and pricks in the following way:—

The grey substance of the spinal marrow being identical with that of the brain, it follows that the blood must have a similar effect upon it. But the electricity generated in the spinal cord below the injury resembles a statical charge in that there is no electromotive force to send it through the nerves. When the leg is pricked, it must be assumed that the equilibrium of the charge is disturbed, and by some means it is caused to flow along the motor nerves, making the limb contract. I think it was Descartes who said that all the lower animals were mere machines. I should be sorry to believe that; all animals which possess a "will" cannot be machines. But I can quite conceive that a decapitated cock and animals in a like unfortunate condition are reduced to the rank of machines. Dr. Stone, in his recently delivered lectures on the electrical conditions of the human body, mentioned six cases of hemiplegia which were tested for resistance, and in each case the paralysed side offered the least resistance. I am disposed to think that this was not due to the fact that degenerated tissue conducts better than sound muscle, but, that in the healthy side the current from the battery had to fight against the current already flowing in the form of nervous force, whereas in the diseased side there was no such counter-current.

Again, we hear a noise for the first time; if that noise continues regularly, we cease to notice it, but as soon as it is discontinued, we are once more sensible of its previous existence. An instance of this is to be found in church-sleepers. They hear the text given out, and then become sweetly oblivious of the rest, and wake up with a guilty start when the sermon is over. These phenomena connected with the auditory nerves closely resemble the extra currents produced on opening and closing the circuit in a coil of wire. It is the unusual rush of the current that makes us attend to a sensation. I regard the case of church-sleepers as a most noteworthy and interesting example of the hypnotic effect of the electric current; an effect which is almost inevitable when the sermon is delivered in monotone.

I should trespass too much on your space were I to dilate further on this very wide subject.—Yours, &c.,

ARTHUR WILLEY.

45, Gladstone-avenue, Noel Park, N., July 7.

IRON WATCHES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the event of the above not having already been brought to the notice of your readers, will you allow me to suggest an iron case for a watch as a very ready specific against magnetism, for any who are interested in dynamo machines. I had a watch made with an iron case last year, and my experience is most satisfactory; the iron, besides being cheap and enabling one to put additional value into the works, affording also a good material for the deposition of any rare metal which may lend a charm to the idea.—Yours, &c,

Westfield, Reading, July 5th, 1886. WALTER PALMER.

THE DEAD TURNS OF DYNAMOS.

BY PROF. SILVANUS P. THOMPSON, D.SC., B.A.

Everyone who has worked with dynamo machines knows that when a self-exciting dynamo is running the electromotive force is not exactly proportional to the speed of the machine, but always somewhat less. Every dynamo acts as if a certain number of the revolutions in a second did not count—as if a certain number of the turns were "dead." The present article is devoted to a discussion of the "dead turns."

Suppose we write E for the electromotive force of a dynamo, and n for the number of actual revolutions per second. Then, *if* the field-magnets were separately excited in some way to absolute saturation we should have,

$$E = n B \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where B stands for the value in proper units of the "cutting" of the saturated magnetic field by the revolving coil in going round once. This quantity B depends both on the armature and on the field-magnets. In the notation employed in my treatise it is the same thing as $\frac{1}{\sigma}(4 A G \kappa)$; or, calling $\frac{G\kappa}{\sigma} = Y$, then $B = 4 A Y$. If we take as our unit of "cutting," the cutting of 10^8 magnetic lines of force as defined in the C.G.S. system, then E will be in volts. But when a machine excites itself it never absolutely saturates its own field-magnets, and therefore E never is as great as n times B. It may be n times something less than B, or may be B times something less than n. This latter way of expressing the matter is the convenient one for our present purpose. We will therefore write the fundamental equation of the dynamos from our new standpoint as

$$E = (n - n') B, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where n' stands for the number of "dead turns."

We have next to find out what n' the number of dead turns depends upon, for it certainly does depend on certain things inherent in the action and in the construction of the machine as well as on the resistances in circuit. And first, we must point out that, quite apart from the question of self excitation, there are two causes of "dead turns" to be found in all machines (even in separately excited and alternate current machines), viz., in the prejudicial actions of self-induction, and of the eddy-currents that arise in badly-designed machines. A very good example of this is afforded by the contrast between the Brush machine, with its old cast iron armature, and the same machine with its new laminated armature. The curves connecting speed and E.M.F., when run in a constant and separately-excited field, are given on p. 190 of my treatise (second edition). The old armature running at 430 revolutions per minute gave the same E.M.F. as the new armature running at 360. The old armature running at 800 gave the same E.M.F. as the new armature at 700. The old armature at 1,200 gave the same E.M.F. as the new armature at 760. The windings being identical, the difference is due partly to quality of iron, but chiefly to saving of eddy

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currents by proper lamination. The dead turns of the old armature exceeded those of the new armature by figures which rose successively from 70 to 100 and finally to 440, increasing much more than in proportion to the speed, more nearly in proportion to its square, as, indeed, is the case with reactions producing eddy-currents. With both armatures there would also be a certain number of dead turns—probably small—due to the self-induction of the armature coils, proportional to the first power of the speed.

Such reactions are present more or less in all machines; but in most well-designed ones eddy-currents and self-induction are reduced to an insignicant minimum. The case taken above was an exaggerated one, but was chosen expressly to show that even in a separately excited dynamo dead turns may arise from these causes.

But we have rather to deal with the ordinary series-wound and shunt-wound dynamos that excite themselves, for they have dead-turns due to a wholly different cause, namely, that they have to spend part of their currents in self-excitation. In all that follows we assume the absence of self-induction and of eddy-currents.

Dead Turns of Series Dynamos.

We must examine the equations of the series dynamo to get at this matter. The equation for the current i is given on p. 279 of my treatise as:

$$i = \frac{1}{\sigma}\left\{\frac{4\,n\,A\,G\,\kappa}{R+r_a+r_m} - \frac{1}{S}\right\};$$

in which expression A is the armature coefficient, G and κ the geometrical and magnetising coefficients of the field-magnet, S the number of magnetising coils, σ the saturation coefficient, R the resistance of the external circuit, r_a that of the armature, and r_m that of the field-magnet coils. This we may re-write as

$$i = \frac{n\,B}{R+r_a+r_m} - \frac{1}{\sigma S}.$$

But, as pointed out in my treatise (p. 284) as a most important point, the quantity $\frac{1}{\sigma}$ is the same thing as that number of ampere-turns which will bring down the effective magnetic permeability of the iron of the machine to half its initial value, or will bring up its state of magnetisation to exactly half saturation. I have called the current that will half-saturate the magnets the "diacritical" current, and denote it by i'. Then, $S\,i'$ is the diacritical or half-saturating number of ampere-turns, and is equal to $\frac{1}{\sigma}$. Hence, the second term of the expression on the right-hand side of the last equation is equal to $\frac{S\,i'}{S}$ or to i'; and so we get

$$i = \frac{n\,B}{R+r_a+r_m} - i'. \quad \ldots\ldots\ldots \quad (3)$$

Now, examine the first term of the expression on the right hand side. We see that $n\,B$ is the same thing as the value of E at that speed if the field-magnets were somehow excited up to absolute saturation. Denote this "maximal" value of the E.M.F. as $\bar{E}$; then we see that this is (by Ohm's law) an expression for the "maximal" current $\bar{i}$ that would be sent through the given resistances by exciting the dynamo independently to saturation and running it at speed n. Or, in symbols,

$$\frac{n\,B}{R+r_a+r_m} = \frac{\bar{E}}{R+r_a+r_m} = \bar{i}$$

giving us for the actual current of the dynamo,

$$i = \bar{i} - i' \quad \ldots\ldots\ldots \quad (4)$$

This is a proposition of great interest, due to Dr. Frölich, and may be stated in words as follows: *The actual current of a series dynamo is always equal to the difference between the maximal current* (at the given speed and with the given resistances, as above defined) *and the diacritical current.*

Now go back to equation (3). It is clear that if i can be written in terms of a speed, a constant B and the resistances, the diacritical current i' may be similarly written, or

$$i' = \frac{n'\,B}{R+r_a+r_m}. \quad \ldots\ldots\ldots \quad (5)$$

Here, obviously, n' is that speed at which the dynamo must be driven, so that if its field-magnets were separately excited to saturation, it would send through the given resistances a current equal to the half-saturating or diacritical current. Put this expression for i' into equation (3) and we get this result:—

$$i = \frac{n\,B}{R+r_a+r_m} - \frac{n'\,B}{R+r_a+r_m}$$

or,

$$i = \frac{(n-n')\,B}{R+r_a+r_m} \quad \ldots\ldots\ldots \quad (6)$$

Comparing this result with equation (2) we see at once that we have here come back to the dead turns, and that equation (5) connects together directly the dead turns and the diacritical current. Hence we get for the dead turns

$$n' = \frac{i'\,(R+r_a+r_m)}{B}$$

or, putting in the value of B,

$$n' = \frac{\sigma\,i'\,(R+r_a+r_m)}{4\,A\,G\,\kappa}$$

But

$$\sigma = \frac{1}{S\,i'}$$

Hence

$$n' = \frac{R+r_a+r_m}{4\,A\,G\,\kappa\,S} \quad \ldots\ldots\ldots \quad (7)$$

This gives us some very definite information about the dead turns. In the first place, the dead turns are the same at all speeds of the machine (neglecting the slight effects of self-induction and eddy currents). In the next place, the dead turns increase with the resistance of the circuit. They can be diminished, however, by increasing the number of coils of wire on the armature, or by increasing the number of coils of wire on the field-magnet, provided at the same time the gauge of wire be increased so that r_a and r_m are not altered. Lastly, looking at G and κ, which depend on the quality, quantity, and form of the iron, we see that the better the magnetic circuit of the dynamo is the fewer will be the number of dead turns. Knowing, as every electrical engineer does, how disadvantageous high speeds are, both from the electrical and from the mechanical point of view, the great importance of saving dead turns is at once apparent. And it is satisfactory to observe that those very means that must be taken to diminish dead turns—namely, reducing internal resistances, and so designing the ironwork as to get the very best magnetic circuit—are already known for other reasons to be the essentials of a well-designed and efficient dynamo.

The next point to consider is the bearing of the above matters upon the least speed of excitation. It is known that for every given dynamo put in a circuit of given resistance there is a certain speed to be found such that, if run below that speed, the machine will not excite itself at all. This can be readily found by calculation from equation (3) or from equation (6). For, give to n a particular value n_1, such that $i = 0$, and we obtain an expression of the conditions for the limiting case, where the machine just does not excite itself. Equation (3) then becomes

$$0 = \frac{n_1\,B}{R+r_a+r_m} - i'$$

or,

$$n_1 = \frac{i'\,(R+r_a+r_m)}{B}$$

But, by equation (5) $i' = \frac{n'\,B}{R+r_a+r_m}$,

whence

$$n_1 = n';$$

that is to say n_1, the least speed of self-excitation, is the same thing as the dead turns. This result is obtained even more immediately from equation (6), in which, if one writes n_1, for n and equates to zero, the equality of n_1 with n' is at once evident.

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It appears, then, that the least speed of self-excitation also depends upon the resistances of the circuit, and on the goodness of design and quality of iron in the magnetic circuit. It is because the least speed of excitation varies with the resistance of the circuit that I object to its being called the "critical speed" of the dynamo, a term given, wrongly, as I think, by some. I hold that this term ought to be reserved for the speed that is the proper one for self-regulation in the compound dynamo; which speed does *not* vary with the resistances of the circuit. The critical speed of self-regulation depends on the machine itself, not on anything in the circuit. The least speed of self-excitation depends on the resistances of the circuit as well as on those of the machine. Therefore, to call this the critical speed *of the machine* would be misleading. I prefer the term "dead turns."

Dead Turns of Shunt Dynamos.

It is easily shown that a similar argument is applicable to the shunt dynamo. Here, also, we may begin by writing

$$E = (n - n')B \quad . \quad . \quad . \quad . \quad . \quad , \quad (8)$$

This should be compared with the equation for the shunt-dynamo on p. 291 of my book,

$$E = \frac{1}{\sigma}\left\{4nAG\kappa - \frac{r_s r_a\left(\frac{1}{R}+\frac{1}{r_a}+\frac{1}{r_s}\right)}{Z}\right\},$$

where Z is the number of windings in the shunt-coil. The quantity $\frac{1}{R}+\frac{1}{r_a}+\frac{1}{r_s}$ is the same thing as the whole conductivity of the machine with its circuits, from terminal to terminal, and may be writen $\frac{1}{\mathfrak{R}}$, where $\mathfrak{R}$ is the resistance of the system from terminal to terminal. Remembering also that there will exist a diacritical shunt current i'_s such that Zi'_s ampere-turns will half saturate; also that $r_s i'_s$ may be written as a diacritical number of volts e', we may insert these and write

$$E = nB - \frac{r_a}{\mathfrak{R}}e'; \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

or, remembering the relation between the volts at terminals e and the whole E.M.F. to be

$$\frac{e}{\bar{E}} = \frac{\mathfrak{R}}{r_a} = \frac{e'}{E'},$$

we have $E = nB - E'$

or $E = \bar{E} - E' \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$

where $\bar{E}$ is the maximal value of the electromotive force of the armature (at that speed) and E' its diacritical value.

Comparing equation (8) with equations (9) and (10) we see that

$$E' = n'B = \frac{r_a}{\mathfrak{R}}e' = \frac{r_a r_s}{\mathfrak{R}}i'_s$$

and $$n' = \frac{r_a r_s i'_s}{B\mathfrak{R}}$$

or, putting in for B its value $\frac{4AG\kappa}{\sigma}$

$$n' = \frac{\sigma i'_s r_a r_s}{4AG\kappa\mathfrak{R}};$$

and, since $$\sigma = \frac{1}{Zi'_s}$$

$$n' = \frac{r_a r_s}{4AG\kappa Z\mathfrak{R}} = \frac{1}{4AG\kappa Z}\left\{r_s + r_a + \frac{r_s r_a}{R}\right\} \quad . \quad (11)$$

from which it appears that in the shunt dynamo the dead turns are diminished by increasing the windings on armature and field-magnets and by bettering the magnetic circuit; but that they depend on the resistances in a more complex way, the internal resistances going to increase the dead turns, the external resistance helping to diminish them as it increases, but increasing them as it diminishes; the dead turns becoming infinitely great when the machine is short-circuited.

For compound-wound machines several curious cases arise, and the calculation of the dead turns is less simple.

LITERATURE.

New Theories of Matter and of Force. By WILLIAM BARLOW. [Sampson Low, Marston, Searle, and Rivington. 1885.]

My doxy is orthodoxy, your doxy is heterodoxy is what each man practically says, although when driven into a corner he falls back upon authorities. It must of necessity be that every one who thinks for himself is more or less heterodox. If it were not so knowledge would be finite, and we should, in some branches at least, have almost reached the bounds. Many of our so-called scientific men act as if they really had explored the uttermost regions, and that no new fields were left for science to conquer. Their dicta are to be accepted without question, and woe to the poor wight who presumes to criticise. History is forgotten or ignored, as are facts; for, notwithstanding the intense conceit of modern science, which leads to hero-worship such as the world never knew before the nineteenth century, facts will prove too strong for theories. The Assyrians, Egyptians, and Greeks framed theories to suit their facts; the moderns have done nothing more. The theories differ in that the latter have to suit more facts, and a thousand years hence new theories will be in vogue to suit the extended accumulation of facts. We are not much concerned with new theories; what we really want is new facts. Given the latter, the former can take care of themselves. So far as we know—with, perhaps, a single exception—no theory ever advanced or generally accepted is entirely satisfactory. These are our views concerning theories, and we look on Mr. Barlow's as one more added to the number, one which may or may not force itself into prominence, gain adherents, be accepted for a time, to be in its turn replaced by another. It must not be thought from what we have said that we in any way despise those who put forward theories; not so, we believe the work they do is extremely valuable, but it should not be put before the obtaining of facts. The theorist inventor is the generaliser, and the man who can generalise is almost as valuable to the world as the man who can investigate.

It is almost impossible to attempt to abstract the theory of Mr. Barlow, so we shall as far as possible allow him to speak for himself. Briefly, he puts on one side the idea of sixty odd elements, and believes the matter with which we are acquainted to be derived in all its forms from two differently compressible ethers, which, at the creation of inorganic matter, had a force impressed upon them from which they have ever since been endeavouring to recover. Mr. Barlow says:—

"All matter consists of two elementary substances, which when uncombined, and not subjected to extreme pressure, resemble gases in that they are compressible and elastic, and that as they are freed from pressure their tenuity becomes practically unlimited.

"They differ from each other in that when, being under the same initial pressure, the same increment of pressure is applied to both, the one has, in all cases, a greater increment of contraction than the other, and we accordingly designate them *the more readily compressible ether* and *the less readily compressible ether*.

"At some low pressure the density of the more readily compressible ether is less than that of the less readily compressible ether, and thus a certain pressure is conceivable, subjected to which the two ethers have the same densities. and which forms, therefore, a critical point of such a nature that for equal pressures upon the two ethers below it, the less readily compressible ether has the greater density, while for equal pressures above it the more readily compressible ether has the greater density.

"These elemental ethers are distinguishable from gases by the far greater fineness of their ultimate particles, if the fact of their elasticity requires us to suppose the existence of such, so that for all practical purposes they are to be regarded as homogeneous. And they also differ from gases in requiring a far greater force of compression to cause them to approach the greatest possible condensation.

"Some cohesion or stickiness subsists among the ether particles at all densities, both between particles of the same kind and particles of divers kinds of ether; the law

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which regulates the degree of this cohesion being that the total amount of cohesion in any given mass of the same kind of ether is constant whatever the density. To put this hypothetic law in algebraic form :—If a given mass of ether is in the form of a cube, the force necessary to just overcome the cohesion subsisting, say, in a plane section taken parallel to one of the faces of the cube, and *simultaneously* to break away particle from particle throughout this section, is constant whatever the magnitude of the cube, and therefore the force necessary to overcome the cohesion in a unit of such surface, and which force we may take as the unit of the force of cohesion, varies as $\frac{1}{l^2}$, if l be the length of a side of the cube.

"In the case of cohesion between two different kinds of ether it is supposed that the density of the less dense of the two regulates the law just stated.

"The cohesion, which thus increases with increase of density, modifies the expansive force of the ethers, so that as they are more and more highly condensed they manifest less and less force of elastic expansion on release from pressure, till at a sufficiently high condensation they manifest none.

"Further, in the case of extremest condensation the viscosity of the ethers, *i.e.*, the degree of resistance they oppose to the relative motion of their parts, becomes indefinitely great, so that they reach a perfectly solid state.

"Finally, the ether particles, like all matter with which we are acquainted, have the property of inertia.

"It is supposed that the origin of the two ethers just described, preceded in time the application of any external force affecting them ; and in their primary condition they may be conceived as without motion, or regularity of disposition in space, and uncompressed."

Starting with these fundamental assumptions, the author goes on very ingeniously to show how the various phenomena connected with electrical and other branches of science are explained by them. We cannot enter into any discussion of the "theory," as, so far as we can see, such a course would serve no practical purpose. Any reader interested in the subject must peruse the work itself.

OLD CABLE STORIES RETOLD.

BY F. C. WEBB.

(*Continued from page 430, Vol. XV.*)

The Persian Gulf Cable of 1863-4.

Although the cable laid from Kurrachee to Suez, for the Red Sea and India Telegraph Company, had proved a costly failure to our Government, and consequently to the country—for the four per cent. absolute guarantee for fifty years saddled the country with a considerable sum—yet so determined was Government to obtain telegraphic communication with India that steps were at once taken towards accomplishing that object by means of land lines, *vid* Constantinople and Bagdad to Bussorah and Fao, and thence by a submarine cable along the shallow waters of the Persian Gulf to Kurrachee, where the land lines of India had their western terminus.

The history of how this line was initiated does not belong to the subject of "Old Cable Stories Retold." It must, however, have been very shortly after the failure of the Kurrachee-Aden and Suez cables that Lieut.-Col. Biddulph, R.A., was engaged to erect a land line with two wires from Constantinople through Bagdad to Fao.

The late Lieut.-Col. Patrick Stewart (then Major) was intrusted by the Government of India with the superintendence of the work of establishing the cable from Fao to Kurrachee, touching at Guadar (on the Mehran coast), Mussendom (on the Arabian coast), and Bushire (the principal port of Persia).

The construction of the lines through Persia was entrusted to Lieut.-Col. Champain, R.E. (then Captain), and Sir Arnold Kemball, H.M. political agent at Bagdad.

A land line with two wires was also being constructed along the Mekran coast, between Kurrachee and Guadar, under the superintendence of the late Mr. Isaac Walton, the route having been previously surveyed by Sir Frederick Goldsmid. Lieut.-Col. Stewart's first step was to take the advice of scientific men as to the type of cable to be employed, and it was finally decided on as follows :—A copper conductor, to weigh 225lb. per nautical mile, to be formed by a process proposed by Mr. Latimer Clark, which was to have the advantages of a strand conductor, viz., immunity from breakage inside the insulating medium, combined with the advantage of the smaller surface given by a single cylindrical conductor over one composed of strands. To accomplish this the copper was to be formed by four pieces having each the section of a quadrant of a circle. Four of these, properly placed, would form a circular conductor, and were to be kept in place by a fifth piece—a tube—in which the other four pieces were placed. The mode of manufacture was to cast the five sections in stout bars, to be placed together, and then drawn down to the required size. The conductor thus formed was to be covered with three coatings of gutta percha, with Chatterton's compound between the coatings.

There was no single contract entered into for the making and laying of the cable. The gutta percha covered copper wire was bought from the Gutta Percha Company, Wharf-road. Tenders were called for the serving of wire covering and outer serving. Mr. W. T. Henley's tender was accepted, being some £13,000 below that of Messrs. Glass and Elliot.

This decision, it may here be mentioned, resulted in the amalgamation of Glass and Elliot with the Gutta Percha Company soon afterwards, forming the Telegraph Construction and Maintenance Company. Messrs. Bright and Clark were engaged not only to watch the manufacture of the cable, but also to superintend and carry out, without the intervention of any contractor, its shipment and submergence. At the Gutta Percha Works, in Wharf-road, the late Mr. J. C. Laws, assisted by Mr. F. Lambert, tested the single coils of wire, and made certain careful experiments on the effects of temperature on the resistance of gutta percha, and from this data curves were formed by means of which the observed resistance at any temperature could be reduced to that which any particular wire tested would give at the chosen standard temperature of 75° F., to which temperature all tests were reduced, and were thus directly comparable whatever the temperature might be at which the test was performed. At Mr. Henley's works I superintended the testing, assisted by Mr. Afred Brasher, Mr. J. T. Woods, the late Mr. T. Alexander, and the late Mr. E. Donovan.

There was one fault that occurred in one of the sections which is worth mentioning. It was very minute and variable ; but what puzzled us most was that with high battery power it increased its resistance, even where reversals were used. It was whipped by a clock night and day with high battery power, and we were at last able to localise it by the loop test to within a short length. This was cut up, and when reduced to within a few fathoms the core was stripped, and the fault found to be caused by a small stone pressing into the gutta percha. The theory that accounted for its increase in resistance with high battery power was that the strong currents decomposed and consequently destroyed the film of moisture that laid between the stone and its matrix in the gutta percha. It gave us a deal of trouble, but we were proud of routing him out at last.

The work of manufacture proceeded, of course, night and day, and some of our staff had to be there at night, for our tests were the only tests taken, Mr. Henley being satisfied with them. If anything had gone wrong with them between, say, 10 p.m. and midnight, I am afraid that the attractions of North Woolwich Gardens, then in full swing, would have had much to answer for.

It soon became necessary to think about ships. The cost of sending 5,000 tons of cable (exclusive of tanks, water, and machinery) round the Cape in steamers would have been very great. The question of employing sailing ships to take the cable to Bombay and there utilising the large paddle frigates of the disbanded Indian Navy was therefore carefully considered at the India Office and found to work out cheaper than steamers all the way. There was every prospect of calm

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weather, and even if cutting and buoying, on account of strong head winds, should become necessary, there could be no great delay or risk, as the depth of water along the whole line did not exceed sixty fathoms. Sailing ships were consequently decided on and tenders sought. There were, of course, a number of tenders sent in, and it must have taken a considerable time to sort them down, judging from what I myself witnessed of the same process when two ships only were required for the second Persian Gulf cable in 1868; but I had nothing to do with that part of the work in 1863. At last the following sailing ships were taken up:—The "Tweed" (formerly the "Punjaub," paddle frigate of the Indian Navy), the Assaye (formerly also a paddle frigate of the Indian Navy), the "Kirkham" (an iron ship), the "Marion Moore," and the "Cospatrick," a teak ship, built at Moulmain. The ss. "Charente," re-christened the "Amberwitch," was also bought and entirely refitted with new deck houses, &c., and re-rigged, previous to her being fitted with tanks and deck machinery as a permanent repairing ship, to be stationed at Kurrachee for the maintenance of the line.

It is curious that although a repairing ship was thus thought of and provided from the first, and although a large staff, which comprised numerous experienced and highly qualified electricians, was carefully selected for the permanent service, no person was engaged who had ever even seen a telegraph cable repaired. The ship was to be commanded by Lieut. Arthur Stiff, I.N., who had for years been engaged under Captain Constable, I.N., in surveying the Persian Gulf, and on whom would have devolved the duty of repairing the cable at the very first break-down, although his great knowledge of the Gulf could scarcely have compensated for his total inexperience in submarine cable engineering.

The ships were each fitted with three cable tanks, with Newall's patented cones and rings, a royalty being paid to Mr. R. S. Newall, although by law Government need pay no royalties. The cones were built up of wood, secured by angle irons to the bottom of the tanks. The rings were of gas pipe, with radiating arms, having a short piece telescoping into their ends, with set screws to clamp them, so that when once adjusted to any particular height the ring could not move horizontally. To resist upward pressure, straight pieces of gas pipe were attached to the radiating arms, and these pieces passed through the deck, cast-iron collars being fixed to the deck, these collars having screws to clamp the uprights in. Thus the rings—when lowered by their tackle to any position—as the surface of the coils lowered, were held rigidly in position. Loops in the rings, temporarily closed at their mouths by an iron block held by two tapered pins, permitted the lower end of the coil to pass up practically inside the ring; for on knocking out the two pins the block fell to the bottom of the tank, and the part of the cable leading to the next tank was inside the ring, thus allowing the bight to pass up out of the tank without any unscrewing of bolts to open the ring. On the second Persian Gulf cable I improved this arrangement to a self-acting opening piece since adopted by the India Rubber Company and the French Government. Each sailing ship, except the "Cospatrick," was fitted with a paying-out machine, so that there was no occasion to shift machinery from one ship to the other. The frames were of wood, the drum overhanging, with a break for contingencies on the drum itself. The working break pulley, for ordinary strains, was within the frame. Stern sheaves were also fitted to each ship, but no bow sheaves.

The "Amberwitch" had bow and stern sheaves, a paying-out gear, and picking-up machine. The latter had overhanging drum with internal spur gear into which the pinion worked, thus preventing any strain coming on the spokes of the drum. I believe this was the first instance of internal spur gear being adopted, or, indeed, of a picking-up machine with overhanging drum. The after knife of the machine could be made to fall away from the drum by merely pulling out a large cutter having a loop handle to it, so as to allow of the turns being taken off the drum. The bow sheave was countersunk into the side cheeks, so that by no possibility could the cable or rope get between the flange and casting.

A Gwynn centrifugal pump and engine were fitted to each ship for pumping up the tanks. Thus equipped, the ships took in their cable, in some cases two at a time, and then were taken to the Victoria Docks, where the cable was decked over in each tank. The ships left the works or Victoria Docks in the following order:—"The Marion Moore," Aug. 15th, 1863, Mr. E. Donovan in charge, with 174·92 N.M. of deep sea; "The Kirkham," Sept. 12 or 13, 1863, Mr. Walker in charge, with 181·25 N.M. of deep sea, and 6·36 L.M. of shore end; "The Assaye," Oct. 2nd, 1863, Mr. J. T. Woods in charge, with 367·98 N.M. of deep sea; The ss. "Amberwitch," Oct. 21st, 1863, with 12·5 N.M. of shore ends and tapers; "The Tweed," Oct. 24th, 1863, Mr. Moseley, with 347·53 N.M. of deep sea; "The Cospatrick," with 103·15 N.M. of deep sea, 23 N.M. of shore end, and 12 N.M. of double shore end. This ship had also five lengths of experimental cable of different types by different manufacturers. The total of cable was therefore 1,228·27 N.M., excluding the lengths of experimental cables.

ON THE SEAT OF THE ELECTROMOTIVE FORCES IN THE VOLTAIC CELL.

Prof. O. J. Lodge communicates the following, from Dr. W. Ostwald, to the *Phil. Mag.* for July:—

Riga, June 2, 1886.

After reading your memoir on the seat of E.M.F. in the pile, published in last year's *Philosophical Magazine*, allow me to express my full agreement with your views. But I further believe that it will interest you to know that there is a method of directly measuring differences of potential, whether between two liquids or between a liquid and a metal.

The method rests upon a remark of Helmholtz, that a quantity of mercury, if insulated, and arranged to form drops quickly beneath the surface of a liquid, rapidly acquires the potential of the liquid. Let T (Fig. 1) be an insulated drop-

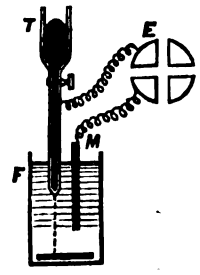

Fig. 1.

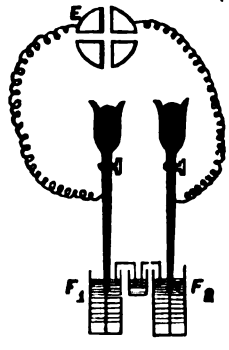

Fig. 2.

ping funnel full of mercury, which drops inside the liquid F through a fine point, and let M be a metal plunged into the same liquid; the electrometer E will indicate the true difference of potential between M and F. I have experimentally convinced myself that by careful regulation of the flow one can get the potential of the mercury to correspond with that of the liquid within about ·01 volt.

In order to measure the potential difference of two liquids, one uses two funnels (Fig. 2), and connects each of the two liquids F_1 and F_2 with a third vessel containing one of them by means of a capillary siphon, so as to prevent any mixture.

I have to thank my friend Dr. Arrhenius for the suggestion of the two funnels. I have found by this method that pretty big potential differences frequently occur between liquids, going up to ·8 or ·9 volt with dilute solutions. The E.M.F. of a Daniell cell appears to be about ·8 volt between zinc and zinc-sulphate, ·3 volt between copper and copper-sulphate; while between zinc-sulphate and copper-sulphate the difference seems practically zero. Nevertheless, since copper salts have shown some hitherto unexplained phenomena, I do not yet quite regard this result as indubitable.

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ELECTRICAL THEORIES.

BY PROF. J. J. THOMSON, M.A., F.R.S.

(*Continued from page 155.*)

The particular solution is propagated at the same rate as ϕ, while the other part of the solution represents a wave travelling with the velocity $1/\sqrt{\mu K}$. Since the part of the solution which travels at an infinite rate satisfies the equation

$$\frac{dF}{dt}+\frac{d\phi}{dx}=0$$

or

$$f=0,$$

we see that the electromotive force due to the change in the vector potential just balances the electrostatic electromotive force, so that until the part of the vector potential which travels at the rate $1/\sqrt{\mu K}$ comes up the resultant electromotive force vanishes. This explains how the electromotive force on Maxwell's theory travels at a different rate from the potential, and a similar explanation will apply to Helmholtz's theory. Helmholtz's equations for a conductor are

$$\sigma\nabla^2 u=(1+4\pi\theta)4\pi A^2\frac{du}{dt}-\frac{d}{dx}\left\{\nabla^2\phi+(1+4\pi\theta-k)A^2\frac{d^2\phi}{dt^2}\right\}$$

where σ is the specific resistance of the conductor; on Maxwell's theory the equations are

$$\sigma\nabla^2 u=4\pi\mu\frac{du}{dt}.$$

These equations differ by terms involving the unknown constant k; but V. Helmholtz's* investigations on the motion of electricity along thin conducting wires show that there is not much hope of distinguishing between the theories by experiments on conductors. We have seen that we can make certain equations which occur in Helmholtz's theory coincide with the corresponding ones in Maxwell's by giving particular values to certain constants. The difference in Helmholtz's and Maxwell's views as to the continuity of the currents is too serious to let us expect that we should ever get a complete agreement between the theories; and, in fact, make as many assumptions about the constants as we may, there are still differences between the theories.

In order to get as general a theory of these dielectric currents as possible, we shall investigate the consequences of assuming merely that these currents are proportional to the rate of change of the electromotive force, and write dielectric current $=\eta$ (rate of change of the electromotive force), where η is a constant which for the present is left indeterminate. In Maxwell's theory $\eta=K/4\pi$, where K is the specific inductive capacity of the dielectric; in Helmholtz's theory, η is also proportional to the specific inductive capacity. We shall denote the components of the dielectric currents by the symbols f, g, h; the components of the conduction current by p, q, r, and the components of the total current by u, v, w, so that

$$u=p+\dot{f}.$$

Let us put

$$\frac{du}{dx}+\frac{dv}{dy}+\frac{dw}{dz}=P,$$

$$l(u_1-u_2)+m(v_1-v_2)+n(w_1-w_2)=\Sigma;$$

on Maxwell's theory P and Σ are zero.

If F, G, H are the components of the vector potential, then by V. Helmholtz's investigation of the most general expression possible for these quantities consistent with the condition that the forces between closed circuits should agree with those given by Ampère's laws,

$$F=\tfrac{1}{2}(1-k)\frac{d\psi}{dx}+\mu\iiint\frac{u}{r}\,d\xi\,d\eta\,d\zeta,$$

with similar expressions for G and H, where k is a constant, and

$$\psi=\iiint\mu\left(u\frac{dr}{d\xi}+v\frac{dr}{d\eta}+w\frac{dr}{d\zeta}\right)d\xi\,d\eta\,d\zeta.$$

Transforming this expression we see, using the same notation as before, that

$$\psi=\iint r\mu\{l(u_1-u_2)+m(v_1-v_2)+n(w_1-w_2)\}dS-\iiint r\mu\left(\frac{du}{d\xi}+\frac{dv}{d\eta}+\frac{dw}{d\zeta}\right)d\xi\,d\eta\,d\zeta$$

$$=\iint\mu r\,\Sigma\,dS-\iiint\mu r\,P\,d\xi\,d\eta\,d\zeta,$$

where dS is an element of a surface at which there is discontinuity in u, v, w.

Let us now consider the equations which hold in a perfectly insulating dielectric.

The rate of change of the x component of the electromotive force in a medium at rest

$$=-\frac{d^2F}{dt^2}-\frac{d^2\phi}{dt\,dx},$$

where ϕ is the electrostatic potential; it also equals $\dot{f}/\eta$, so that

$$\frac{\dot{f}}{\eta}=-\frac{d^2F}{dt^2}-\frac{d^2\phi}{dt\,dx}.$$

Since in this case there is no conduction current $u=\dot{f}$, and the preceding equation for F shows that

$$\nabla^2F=\tfrac{1}{2}(1-k)\frac{d}{dx}\nabla^2\psi-4\pi\mu\dot{f}.$$

substituting for $\dot{f}$

$$\nabla^2F-\tfrac{1}{2}(1-k)\frac{d}{dx}\nabla^2\psi=4\pi\eta\left\{\frac{d^2F}{dt^2}+\frac{d^2\phi}{dx\,dt}\right\}$$

if $\dfrac{dF}{dx}+\dfrac{dG}{dy}+\dfrac{dH}{dz}=\chi$, we get, by differentiating this expression, with regard to x and the corresponding equations for G and H with regard to y and z respectively, and adding

$$\nabla^2\chi-\tfrac{1}{2}(1-k)\nabla^4\psi=4\pi\eta\mu\left\{\frac{d^2}{dt^2}\chi+\frac{d}{dt}\nabla^2\phi\right\}$$

Now, as the dielectric is a perfect insulator, there are no conduction currents, so that the density of the free electricity remains constant, and therefore

$$\frac{d}{dt}\nabla^2\phi=0.$$

From the expression for ψ we see that

$$\nabla^4\psi=+8\pi P=-8\pi\eta\mu\left(\frac{d^2\chi}{dt^2}+\frac{d}{dt}\nabla^2\phi\right)=-8\pi\eta\mu\frac{d^2\chi}{dt^2}.$$

Substituting this value of $\nabla^4\psi$ in the equation for χ, we get

$$\nabla^2\chi=4\pi\eta\mu k\frac{d^2\chi}{dt^2},$$

which represents the propagation of a normal wave with the velocity $1/\sqrt{4\pi\eta k}$.

The transverse wave is propagated with the velocity $1/\sqrt{4\pi\eta\mu}$, so that if the view that light consists of electric or magnetic disturbances be correct, since experiment shows that this velocity is very nearly equal to $1/\sqrt{K\mu}$, we must have $4\pi\eta=K$ or $\eta=K/4\pi$, which is Maxwell's theory. So that if we assume that light is an electric phenomenon, then in those media in which its velocity $=1/\sqrt{\mu K}$ Maxwell's theory that the electric currents flow like an incompressible fluid must be true.

If α, β, γ are the components of the magnetic force, then, since

$$F=\tfrac{1}{2}(1-k)\frac{d\psi}{dx}+\mu\iiint\frac{u}{r}\,d\xi\,d\eta\,d\zeta,$$

we see from Ampère's formula for the magnetic force due to a circuit that

$$\mu\alpha=\frac{dH}{dy}-\frac{dG}{dz}-\mu\frac{dV}{dx},$$

where V is the magnetic potential due to the magnetism in the field both permanent and induced. From these equations we get

$$\mu\left\{\frac{d\alpha}{dy}-\frac{d\beta}{dx}\right\}=\nabla^2H-\frac{d}{dz}\left(\frac{dF}{dx}+\frac{dG}{dy}+\frac{dH}{dz}\right)=-4\pi\mu w+\frac{d}{dz}\left\{\tfrac{1}{2}(1-k)\nabla^2\psi-\chi\right\}$$

* *Ueber die Bewegungsgleichungen der Elektricität für ruhende leitende Körper.* "Gessammelte Werke," Vol. I. p. 603.

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instead of the equation

$$\frac{d\alpha}{dy} - \frac{d\beta}{dx} = -4\pi w.$$

We have been obliged to introduce another assumption here, viz., that the magnetic force due to an element of current is given by Ampère's expression.

We could not assume Maxwell's way of connecting currents with magnetic force, viz., that the total current flowing through any closed curve is equal to the line integral of the magnetic force round the curve, for the result can only be true when the currents flow like an incompressible fluid.

(To be continued.)

MAGNETIC RESEARCHES.*

BY PROF. G. WIEDEMANN.

Since the year 1857 I have published a series of investigations on the relationship between the mechanical and magnetic properties of bodies, and in 1877 a closely related paper on Torsion, in which I proposed to make, in continuation, observations on magnetism. In the meantime other investigators have made researches upon the same subject, which indeed are partly only repetitions and extensions of previous work in slightly different form; but partly also have constituted an actual advance, and in particular points have been supposed to be in opposition to the theory I have proposed. I may therefore be permitted briefly to mention these researches here, and to describe certain new experiments connected with them.

I. Mr. Hughes has investigated the change in magnetic moment of iron and steel, upon torsion, &c., under various conditions, as Wertheim and Matteuci had already done by means of the currents induced in a spiral surrounding a magnetic body.

He has given a series of experiments on the behaviour, during torsion, of iron wires through or round which a current is passed. I have already, in a short note published in English, called attention to the fact that the essential portion of these results had been already observed by myself in the years 1858-60. Nevertheless, Mr. Hughes in further communications after a not altogether correct or quite complete citation of earlier work, has (together with certain experiments following at once from my views) reproduced my theory as new. This theory has thus, in various quarters, been supposed to have originated with him.

Mr. Hughes passes, for instance, alternating currents through a flat iron band, surrounds the middle of this with an induction-spiral, and, in a telephone connected with the latter, hears no sounds; as was to be expected, since, with both directions of the current, the potential of the transverse and circularly-directed molecular magnets upon the spiral is zero. But if the iron band be twisted meanwhile, then, as I have expressly explained, the transversal molecular magnets take up a position inclined to the axis of the band, and partially maintain this position during the detorsion. Hence, under the influence of the alternating currents, they assume positions variouly inclined to the axis, so that the potentials can no longer be zero, or equal to each other; hence the telephone sounds. That upon the sudden springing back of the twisted band the molecular magnets may spring over to the other side, and that then the induced currents run in the opposite direction, is clear. It is equally obvious that the molecules of the iron tape may take up an inclined position upon the lateral approach of a magnet, though not spirally arranged round the axis, and that similar phenomena must result. These conclusions follow at once from my earlier results.

In connection with these and similar experiments, Mr. Hughes proposes the theory (*a*) that each molecule of a magnetic metal is an unalterable molecular magnet; (*b*) that it can be caused to revolve on its axis by means of mechanical and electro-mechanical forces; (*c*) that when there is external magnetic neutrality, the molecules and their polarities are so arranged that they satisfy their mutual attractions in the shortest possible way; and, lastly, (*d*) that if magnetism is produced, the molecules and their polarities become rotated into a given direction in a symmetrical manner, so that a north pole is produced in the one direction and a south pole in the opposite direction. Moreover, also, a symmetrical arrangement is assumed when magnetism is produced, but the circuits of attraction are not complete unless there is a keeper connecting the two poles. Hence Mr. Hughes assumes still further (*e*) a rigidity, which retains the molecules in their positions after the cessation of the active forces.

We have long been acquainted with all these propositions. They agree perfectly, so far as they are correct, with those which I have published after the earlier calculations of Weber; as, moreover, is recognised by Prof. G. Hoffmann, the reporter upon Mr. Hughes's experiments in the *Electrotechnical Journal*. It is only in regard to proposition (*c*) that he thinks Mr. Hughes has the priority. This is, however, not correct. In the second edition of my *Galvanismus*, II. (1) p. 373, § 327 (1871) I say distinctly:—"It is obvious that we may imagine an infinite number of arrangements of the molecular magnets in bodies, with each of which no external action would result. If, for example, they are arranged in circles with their unlike poles in contact, or if their poles have in each space-element all possible directions, this result will follow. The assumption of Mr. Hughes, that I have referred the neutrality of a bar to a "heterogeneous" arrangement of molecules, which is completely different from his theory of neutrality, is thus opposed to facts.

Moreover, it is incorrect that the external magnetic neutrality, whether of a new bar or in one subject to magnetising influences, is conditioned solely by the formation of closed molecular rings, such as Mr. Hughes imagines. This would be possible only with a power of perfectly free rotation of the molecules round their centres of gravity. But since experience shows that they suffer a resistance to this rotation, this arrangement can only be approximately attained; the axes of the molecular magnets must in like manner deviate from the axis of such a ring on all sides. Moreover, there is, *à priori*, no ground why any one direction should have the preference in an absolutely neutral magnet, either for the position of the separate molecular magnets, or for the rings approximately formed by their opposite attractions. The second statement of my proposition quoted above is therefore entirely justified.

Lastly, Mr. Hughes's proposition (*d*), that in visible magnetisation a "symmetrical" rotation and arrangement of the molecular magnets takes place, is only correct in the case of a symmetrical form of the body magnetised and a symmetrical distribution of the magnetising forces.

II. Sir William Thomson has endeavoured to explain the experiments which I made in the year 1858—showing that an iron or steel bar, subjected to torsion during or after passing a galvanic current through it, becomes magnetic—by assuming that the fibres of the bar assume a spiral arrangement upon torsion, and that so that the current also circulates spirally through it. At the same time he himself mentions the difficulty that the effect of torsion is constant in direction up to the strongest current which can be passed through the wire, whilst aelotropy would result only with feeble magnetisation, and moreover is opposed to the action of aelotropy upon the electric conductivity.

The above view is also opposed by the fact that, upon stopping the current through the wire, wires which have thus acquired permanent transversal-circular magnetism have produced in them by torsion a permanent axial magnetism. Moreover, the opposite behaviour of nickel and iron (see below) contradicts this assumption*. But that this cause may have some secondary action at the same time as the rotation of the molecular magnets is hardly to be doubted.

III. According to the experiments of Sir W. Thomson, the behaviour of magnetic bars of iron, on the one hand, is opposed to that of magnetic bars of nickel and cobalt, on the other hand, when subjected to longitudinal tension. Whilst the temporary magnetism of the first increases with the load under

* From the *Phil. Mag.* for July.

* Compare also Ewing's proposal of an experiment on this point, *Phil. Mag.* (5) xiii. p. 423 (1882); *Beibl.* vi. p. 809 (1882.)

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a certain critical value of the magnetic force, above which it decreases, the temporary magnetism of nickel and cobalt decreases below a certain other (much larger) critical value of the magnetising force.

Reciprocally, it follows from the experiments of Barrett, that whilst (as Joule has shown) iron bars lengthen upon being magnetised, bars of nickel, on the contrary, shorten. Cobalt is reported to form an exception and to behave like iron. In these latter experiments, it is true, the purely mechanico-electro-magnetic action of the magnetising coil upon the bar was not excluded.

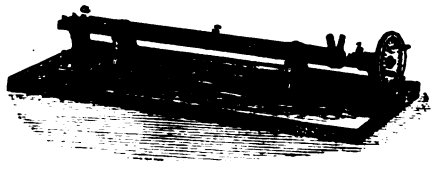
Quite in agreement with this, Mr. Knott has found that when a current has passed through a bar of nickel magnetised longitudinally, it suffers torsion in a direction opposite to that which I found for an iron bar treated in the same way.

Maxwell and Chrystal have formerly endeavoured to refer this torsion, in the case of iron, to the above-mentioned expansion which it suffers upon being magnetised. Wires magnetised at the same time longitudinally and transversely, and therefore in an obliquely spiral direction, ought to expand in this latter direction, and thus to suffer torsion in the direction determined. But with nickel, since, upon being magnetised, contraction instead of expansion takes place, the torsion ought to take place in the opposite direction, as is shown by experiment to be the case.

I have myself endeavoured to refer this phenomenon, observed in my first experiments in 1858, at least in the case of iron wires, to the obliquely spiral direction which the molecules take up in consequence of the two magnetisations at right angles to each other, and which is accompanied secondarily by a displacement of the longitudinal fibres and sections of the wires, of which, in the case of iron, the first is the most important.

The chief proof of my assumption which I had given was the phenomenon, completely co-ordinate with the above results, that a wire equatorially magnetised, whether temporarily or permanently, by a current passed through it, becomes longitudinally magnetised upon torsion.

I have now extended these experiments to the case of nickel wires. They were made essentially in the same way as the former ones. The wire, 52 centim. long and 2 millim. thick,



was stretched east and west between a clamp, *a*, screwed tight, and a clamp, *b*, coaxial with *a*, capable of rotation in an upright, and provided with a divided circle. The wire was placed end on in front of a magnetic steel mirror swinging in a thick copper box, with a fixed clamp at a distance of about 20 centim. from it. The current of a Bunsen battery was led to this clamp by long wires, placed as axially as possible, which ran at first in the direction of the axis of the wire, then coming together in a wide arc, were wound round each other and carried to the poles of the battery. The deviations of the magnetic mirror were read off upon a scale at a distance of 1 metre. In order to determine the intensity of the current as well as the temporary moments of the wires, a wire ring (Fig. 1) of 7 centim. diameter was placed in front of the mirror and coaxial with it, cut through at the bottom, and capable of vertical rotation about a horizontal axle of brass attached to it at its lowest point. The two halves of the axle were provided with copper discs dipping into mercury-troughs. A brass wire was first of all stretched in the torsion-apparatus, the current passed through it and in the proper direction through the wire ring, and this moved axically in front of the steel mirror until the latter showed no deviation, and remained without deviation when the wire was twisted. If, then, the wire ring was turned about its axis into a horizontal position, the deviation of the deflection of the mirror corresponded to the intensity of the current. Employing wires of iron or of nickel the deflection in the vertical position of the wire ring gave the temporary moment, and in the horizontal position the same increased by a quantity proportional to the intensity of the current.

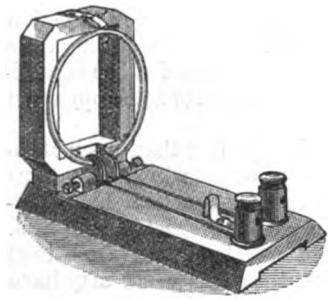


Fig. 1.

Frequently repeated experiments gave decisively the following results:—

If the current passes through an iron wire from the movable clamp to the fixed one, and if the former, as seen in the direction from the movable to the fixed clamp, is rotated in a direction opposite to the hands of a watch, the iron wire acquires a north pole at the fixed clamp, and a south pole with opposite rotation of the clamp. With reversed directions of the current opposite polarities are produced, thus confirming former results. The same takes place after stopping the current.

But if a nickel wire be employed instead of an iron wire, the results are reversed. If the current passes from the movable to the fixed clamp, and if the former be rotated in a direction opposite to that of the hands of a watch, the wire at the fixed clamp becomes a south pole, and with reversed rotation a north pole. Here also the same result is obtained after stopping the current.

Similar results were obtained also, within certain limits, upon repeated torsion in opposite directions. The deviations of the magnetic mirror far exceeded 50 or 100 scale-divisions, with torsions of $\pm 60°$ in the case of wires 2 millim. thick, so that there could be no possible doubt of the facts. The experiments may even be made with an ordinary magnetic needle in place of the reflecting magnet. The effect is less marked with thinner wires.

If the torsion acted only like an extension of the wires, it would not be easy to understand why an equatorially magnetised wire should become longitudinally magnetised by it. If we further assume that the fibres of the wires take up an inclined position, but that the molecules composing them retain their position relative to the axes of the fibres, then in all cases, if the current flows from the movable to the fixed clamp, and the clamp is rotated opposite to the direction of the hands of a watch, the wire would acquire a south pole at the fixed clamp, equally whether it consisted of iron or nickel. The expansion of the fibres might produce under the critical magnetisation an increase of polarisation in the case of iron and a decrease with nickel, but not a reversal of the polarisation.

A simple displacement of the sections, without a consequent rotation of the molecules, would communicate no longitudinal magnetism to the wire at all, and the expansion in length could produce no change.

Hence under all conditions torsion must produce a rotation of the molecules of iron opposite to that which takes place in nickel. I have already referred these rotations to the two simultaneous phenomena just mentioned, namely, to the relative displacement of the longitudinal fibres, and that of the sections of the twisted wires, whereby contiguous molecules suffer rotation in consequence of mutual friction, and in opposite directions in consequence of the two displacements. In iron the friction of the longitudinal fibres is the greatest; in nickel that of the sections predominates.

We must evidently employ these various rotations of the molecules, as I have endeavoured to do, to explain reciprocal phenomena. If the molecules of a wire are placed with their axes oblique by means of two currents passing through and round the wire, its fibres and sections must follow their rotations, as the molecules follow the displacements of the fibres and sections when torsion takes place, and consequently here also nickel must behave oppositely to iron. The change in the length of the fibres can only exert a secondary quantitative change upon the phenomenon.

Hence I believe that the phenomena I have observed cannot be taken simply as secondary phenomena to those observed by Mr. Joule and Sir W. Thomson.

(To be continued.)

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SOME ADDITIONAL FACTS CONCERNING THE REIS ARTICULATING TELEPHONE.*

BY PROF. EDWIN J. HOUSTON.

Whatever the decisions of the United States Circuit Courts have been in the past, or whatever they may be in the future, there can be no reasonable doubt that, in the opinion of the general scientific world, to Reis, and not Bell, will be accorded the credit of having made the great discovery of the methods and apparatus for the electrical transmission of articulate speech. We have elsewhere maintained the following propositions, viz.:—

1st. Reis invented an instrument which he called a telephone, and which he said would transmit speech.

2nd. That this telephone operated by means of electricity, and consisted of transmitting and receiving apparatus.

3rd. That in the hands of Reis it did transmit intelligible, articulate speech; and that credible witnesses are still alive who heard it so transmit speech.

4th. That exact reproductions of the Reis apparatus, operated in accordance with his directions, will transmit speech now.

To the above it is answered, despite the published statements of Reis to the contrary:—

1st. That Reis devised his apparatus to transmit musical tones, and not to transmit articulate speech.

2nd. That there is but one method by which articulate speech can be transmitted electrically, viz., by an undulatory current, and therefore Reis never could have transmitted articulate speech telephonically, since, it is alleged, he did not use the undulatory current. Any, consequently, who imagined that they heard articulate speech through the Reis apparatus must have been deceived.

3rd. That if reproductions of the original Reis apparatus have been made to transmit articulate speech, however exact they may appear, they must have been varied in some important (although inappreciable) respect.

The transparent sophistries of the above answers are, in our judgment, completely swept away by the experiments of Mr. John R. Paddock, of the Stevens Institute of Technology, which although of an early date we have but recently received and had permission to publish. These instruments have been introduced into the overland telephone cases, on appeal to the Supreme Court. Mr. Paddock's experiments appear to clearly establish, what at the outset should have been apparent to any fair inquirer, viz., that the original Reis apparatus, without any change whatever, will transmit intelligible, articulate speech. The apparatus used by Mr. Paddock were the identical apparatus employed by Reis in his lecture before the Physical Society at Frankfort-a-M., in 1861-2. They were obtained by Hon. A. J. Keasbey, from Prof. S. P. Thompson of Bristol, England, who got them from Dr. Theodore Stein, of Franfort, Germany. Dr. Stein got them from Prof. Dr. Böttger, President of the Physical Society of Frankfort, who received them direct from Reis, after the above-mentioned lecture. The story as above told is fully substantiated by testimony taken at Frankfort-a-M.

The following letter from Mr. Paddock will, however, give the particulars at length:—

"Stevens Institute of Technology,
"Hoboken, N.J., Feb. 12, 1886.

"Prof. E. J. Houston, Franklin Institute, Phila.

"I have read with much interest your articles in the London *Electrical Review* relating to the telephone and invention of Philip Reis.

"Having facts concerning the same which have not yet been made public and which are of especial interest at this time I take the liberty of placing them at your disposal. In the summer of 1858 I came into the possession of the Original Bored Block Transmitter and Knitting Needle Receiver, exhibited by Philip Reis before the Physical Society, at Frankfort-a-M., in 1861-2. These instruments were obtained by Hon. A. Q. Keasbey, Counsel for the Overland Telephone Companies, from Prof. Thompson, of Bristol, England, who received them from Dr. Theodore Stein, of Frankfort, Germany, and he in turn from Prof. Dr. Böttger, President of the Physical Society at Frankfort, to whom *Reis himself* gave these instruments after the lecture above referred to. Their history is thus fully proved and their identity has been further established by testimony taken at Frankfort-a-M.

"The instruments were in a good state of preservation when received by me, and required no alterations or additions whatever, with the exception of a wooden support for the needle of the receiver, which was wanting, and a slight mending of the wooden case, which had become broken, evidently during transportation.

"With these instruments I soon succeeded in transmitting and receiving good articulate speech. Musical sounds and songs were easily reproduced, and it is important to remark that when the transmitter was so operating as to transmit musical sounds *best* it was also so operating as to transmit articulate speech *best*, which in view of the oft-repeated statement that the Reis instruments are capable of transmitting the one, but incapable of transmitting the other, is of especial value as showing that the same condition of the transmitter is required for both. The pitch of a musical sound was not the only results achieved by Philip Reis with his instruments, but also amplitude, and, to a good degree, quality also, as is proved by the publications of his day (see *Annual Report* of the Physical Society of Frankfort-a-M., 1861-2. Also, the *Deutsche Industrie Zeitung* for 1863).

"Mr. E. W. Smith, a practical telephone operator, assisted me in this work, and together we were able to transmit and receive many words and sentences in as clear and distinct a manner as in any modern telephone, and this notwithstanding that the instruments we were using were now nearly 24 years old, and that the diaphragm of the transmitter was made of a thin animal membrane, which soon absorbs the moisture of the breath, and then, of course, loses its tension, and fails to respond to the vibrations of the voice.

"In describing the operation of this very instrument, Philip Reis, in his lecture before the Physical Society, at Frankfort, makes the following statement:—

"'If, now, sounds or sound combinations are produced in the neighbourhood of the block, so that sufficiently powerful waves reach the opening *a*, then these sounds cause the membrane *b* to vibrate. At the *first condensation* the *hammer-like wire d is pushed back*, at the *rarefaction* it *cannot follow the retreating membrane, and the current* traversing the strip *is broken*, until the membrane forced by a new condensation again presses the strip (proceeding from *p*) against *d*. In this way *each sound wave causes a breaking and closing of the circuit.*'" (The italics are Mr. Paddock's.)

This is the description chiefly relied upon to prove that the Reis instrument operates by means of a broken current, and hence is incapable of transmitting speech, for it is maintained a current broken at each vibration cannot transmit speech, and Reis distinctly says himself that the current is thus broken, therefore, &c.

"We have endeavoured experimentally to test this most vital point so far as regards Reis and his instrument. Whether there are minute breaks in the current during the ordinary use of a microphone transmitter is a matter still in doubt and one which only indirectly bears upon this question.

"The real question is, Did Philip Reis so operate his telephone as to break the current (as he supposed he did), and if so did he obtain speech in that way (as he says he did)?

"We have operated the Reis instruments in exact conformity to his description and to this very paragrrph of that description. When thus operated 'The hammer-like wire is pushed back, but cannot follow the retreating membrane and parts from it." A continual humming is kept up as the two platinum contacts strike one another, and a succession of sparks indicate the parting of the electric current at each vibration.

"While so operating in exact accordance with the description of Reis himself the following sentence has been distinctly transmitted and received:—

"'William H. Vanderbilt died suddenly at his house on Fifth-avenue yesterday. He is said to have been worth two hundred million of dollars,' a sentence of twenty-three words, which of itself is clear proof that articulate speech can be transmitted in the Reis instrument when used with the so-called broken current. We are at present engaged in ascertaining the extent to which this old instrument will transmit speech under these conditions, and the work thus far done points to the conclusion that it is far greater than has hitherto been supposed. Photographic records will also be obtained of the vibrations produced under these circumstances, which will form an interesting subject for study, and lead to more positive conclusions.

"With reproduced forms of a later Reis instrument, viz., the cubical box form, we have transmitted speech at greater length—one sentence consisting of fifty-six consecutive words. A full statement of these experiments appears in the record of the Overland Telephone Cases, now on appeal to the Supreme Court.—With esteem and regards, very truly yours, JOHN R. PADDOCK,
"Instructor in Physics and Chemistry."

The importance of the above statements, substantiated as we do not doubt they will be, can hardly be over-estimated. If established, they sweep away completely the broad claims that the Bell Telephone Company have been so pertinaciously endeavouring to establish for Bell. They completely dispel the legal mists, that have so skilfully been maintained around the early labours of Philip Reis, and hasten the time when the general public will be ready to do what the general scientific public, the world over, has already done, viz., accord to Philip Reis the credit due to his wonderful discovery. The importance of Mr. Paddock's experiments will, perhaps, be the better understood by examining some of the recent decisions in the Circuit Courts on the legal value of the Reis apparatus as anticipations of the articulating telephone of Bell. In the recent New Orleans Telephone decision, in the case of the American Bell Telephone Company, *et al*, *v.* the National Improved Telephone Company, *et al*, Judges Pardee and Billings in their decision, spoke as follows:—"From the evidence submitted in the case it seems clear that now, in the present state of the art, neither that Reis' instruments nor any reproduction of them can be made

* From an advance proof of paper read before the Franklin Institute.

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to transmit articulate speech except by changes of some form in the instruments or by the employment of Bell's method.

"We, therefore, conclude that neither Reis nor his successors anticipated the invention of Bell as set forth in the fifth claim of his application and patent, and as illustrated by Fig. 7, described in his accompanying specification."

But if the original apparatus, without any change will speak, what then?

In the American Bell Telephone Company *v.* Amos E. Dolbear, *et al*, Judge Lowell, on August 25th, 1883, in giving the opinion of the Court in this case said, "The defendant now testifies that the Reis instrument can be made to transmit speech, under some circumstances, if operated in the way which Bell has shown to be necessary. . . . . The experiment made in the presence of counsel, which was intended to prove the correctness of the defendant's present opinion, was an utter failure. But if it be admitted that the Reis instrument is capable of such use, to a very limited extent, and after a change in its proportions, and when used in a way which the inventor did not intend, still I am of opinion that it was not an anticipation of Bell."

But if the original apparatus without a change in its proportions, and when used in a way which the inventor intended, will transmit speech, what then?

Alluding to the success in making the apparatus described in Fig. 7 of Bell's original specification talk, Judge Lowell says :—"This great result has been reached by Mr. Bell entirely through the improvements described in his second patent (1877 patent), such as the substitution of a metal plate for a stretched membrane, and some others," and these early unsuccessful efforts he says are "now immaterial, for it is proved that the instrument will do the work, whether the inventor knew it or not, and in the mode pointed out."

But if it be now proved that the original apparatus will do the work, which its inventor claimed it would do (not which he hoped it would do, or was ignorant it would do), what then?

In a case that has been so full of surprises, as the telephone litigations, we must confess to considerable curiosity as to what the Courts and the legal advocates of Bell will do with the above evidence.

The author has not personally tried the experiments referred to, but hopes to do so on the first opportunity. Mr. Paddock promises to give him additional information at an early day.

Central High School, Philadelphia, June 16, 1886.

PHYSICAL SOCIETY.—June 26th.

Prof. W. E. AYRTON, F.R.S., Vice-President, in the chair.

Mr. E. M. Langley was elected a member of the Society. The following communications were read :—"On certain Sources of Error in connection with experiments on Torsional Vibrations," by Mr. HERBERT TOMLINSON. During a long series of researches on the torsional elasticity and internal friction of metals, the author has come across the following sources of error in connection with torsional vibrations. In some of the earlier experiments a horizontal brass bar was suspended by a wire and oscillated, the times of oscillation being observed by the ordinary lamp, mirror, and scale. The moment of inertia was varied by sliding two brass cylinders, suspended from the bar by fine wires, backwards and forwards along it. It was then found that under certain conditions the bar executed a few vibrations of rapidly decreasing amplitude, came to rest, and then commenced to swing again, the amplitude increasing to a maximum, again decreasing, and so on. This effect was finally traced to an approach to synchronism between the time of oscillation of the bar and that of the small cylinders about their axis of suspension, the absorption of energy being due to these being set in vibration. The effect entirely disappeared upon clamping the cylinders rigidly to the bar. On another occasion, however, the old phenomenon reappeared, and, after much time spent in investigating it, was found to be due to a somewhat similar cause, a near approach to synchronism between the periods of torsional and pendulous vibrations. If the axis of the wire passed accurately through the centre of mass of the vibrator, this would not occur; but this condition it is practically impossible to fulfil. Another source of error lies in the fact that in a wire recently suspended the torsional vibration period will always be found to be slightly greater than when it has been suspended for some time, and frequently oscillated.

"On a Mode of Driving Electric Tuning Forks," by Prof. S. P. THOMPSON. It is invariably found that the frequency of an electrically maintained fork is continually changing. This great inconvenience the author believes to be due to the fact that the impulses are given to the prongs at a disadvantageous moment, namely, when they are at the extremities of their swings. It is desirable that the impulse should be given at the middle of the swing, and to effect this it is suggested that each fork should make and break the circuit of the magnet influencing the other one, and it was shown how the electrical connections could be made to effect this in a simple manner.

"A Further Note on the Formulæ of the Electro Magnet, and of the Dynamo," by Prof. S. P. THOMPSON. In a paper recently communicated by the author it was shown that an expression given by Fröhlich for the intensity of magnetisation in terms of the magnetising force, was nearly identical with one derivable from a simple law enumerated by Lamont. In a recent paper Fröhlich has further developed this law, and in the present paper the author has extended Fröhlich's results and has applied them to the various forms of dynamos.

COMPANIES' MEETINGS & REPORTS.

United Telephone Company (Limited).

The sixth annual ordinary general meeting was held at the City Terminus Hotel, Cannon-street, on the 6th inst., under the presidency of Mr. James Brand.

The SECRETARY (Mr. Thomas Blaikie) read the notice convening the meeting. The report of the Directors has appeared in *The Electrician*.

The CHAIRMAN said: I hope you have had your report soon enough on this occasion. You complained before of not having it soon enough, so we have sent it out a few days earlier. You will have noticed from our report that, so far as our accounts are concerned, we have entirely separated the business of our metropolitan area from the general business of the Company. As regards the capital expenditure, we have spent £143,600 in our metropolitan district, and £43,000 on instruments now in use in the metropolitan district, and by the subsidiary companies. This shows an increase of about £26,000 as compared with last year, and it has resulted in an increase of gross revenue of nearly £20,000, and an increased net revenue of about £11,000. I may say that this net increase would have been somewhat larger, but we thought it right to debit revenue with the whole cost incurred through the snowstorm of January last. I may say that we should have been justified in debiting capital with a good deal of the amount, as while replacing poles and wires that had been damaged, we took the opportunity of making good provision for our increasing business by strengthening our poles and running cables which would tend to diminish the multitude of wires. As to the dividend, we propose to put £10,000 to the reserve fund, and we have already placed £2,700 to the same fund which arose from exceptional profits. The reserve will now, therefore, be about £97,000, and we have also made a provision in excess of maintenance for the depreciation which must always go on in the metropolitan system. As to the working and progress of our business, we have been making great alterations and improvement in our whole system and in all our switch rooms, but notwithstanding this, we have increased our exchanges during the year in the metropolitan district from 19 to 25, our messages over the wires have increased from 15,500,000 to 17,760,000, and our subscribers have increased from 3,820 to 4,393. The National Telephone Company has 49 exchanges, Lancashire and Cheshire 43, Northern District 10, Telephone Company of Ireland 4, Western Counties and South Wales 9, and the South of England 22, giving, with the United Company, a total gross income of nearly £300,000 per annum for the United Kingdom. Besides the additional exchanges we have call rooms at Kilburn, Clapham, Balham, Norwood, Coleman-street, Oxford-court, Chancery-lane, Heddon-street, and the Houses of Parliament; and we are nearly ready for opening stations at the Temple, the Law Courts, Herne Hill, Holloway, and Earl's-court. These do not exactly bring direct profit to the Company, but they help to popularise the business, and will form bases for future exchanges. I am sorry that while we give all these facilities we find people rather slow to avail themselves of these advantages. Habit, you know, is very slow to change. Even the arrangement we made with the General Post Office (as to which we thought ourselves rather clever), whereby subscribers are allowed to speak their telegraphic messages instead of sending them by hand, has been made use of to only a very small extent. Experiments are being made daily by all concerned in long-distance telephony, and I believe that we are approaching within reach of connection by telephone between London and some of our chief ports. We ourselves have spoken to Bristol from Westbourne-park, and I understand that distinct conversation has taken place between Uxbridge and Liverpool. The great difficulty, however, is to get a line of wire clear from the influence of other electrical wires, in which the current is much stronger, and destroys our current by induction. We are continually told that our prices are too high, and that we should get a great increase to our subscribers and over our system if we lowered our rates. We have lowered our rates to a certain extent, and we shall do so when it is advisable. Any £20 business subscriber can now be joined up with his private house for £12. You must, however, remember that every additional subscriber joined up increases the difficulty and the expense of working the system, and it is much better to try and give a perfect service at a reasonable charge than by reducing the cost to get so many subscribers at a low rate as would render our difficulties insurmountable. This is also the experience of the American and Continental exchanges. As at present advised, therefore, we do not think a lowering of the rates would be beneficial. In a small town with a few subscribers to an exchange a lower tariff can be profitably adopted; but when the communication is to thousands instead of hundreds the cost and the complications are immensely increased. In America, where the number of subscribers is very large indeed, many business firms pay an additional sum for being upon separate express systems. The lowest charge in New York is £30 per annum, and in Paris it is £24. Our system is so valuable in consequence of the great number of subscribers who can communicate with one another. Mr. Vaill, the chairman of the Telephone Company of America, says from experience, that the service is divested of half its value the moment half the people become affiliated to another system. We are very sorry we have again to write off a large sum for law expenses; and we had hoped that decisions of previous years would have been sufficient to maintain our patent rights without further litigation; but we are paying the usual penalty of success. So long as money is to be made by it there will be persons ready to convert other people's inventions to their own purposes. Mr. Winterbotham, one of our solicitors, says that Mr. Edison in his patent uses a diaphragm which receives the sound waves from the voice. In a case which we have recently had to go to the Court with, Messrs. Bassano and Slater used a vibrating mouth tube and back board, which

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served the same purpose, and they contended that this was not an infringement because they used no diaphragm. Mr. Justice North, however, decided last year that it was an infringement, but the defendants, not satisfied with this decision, carried the case to the Court of Appeal, and last Monday that Court unanimously confirmed Mr. Justice North's decision. The worst of it is, unfortunately, that those gentlemen who infringe are not always in a position to pay the penalty of their misdeeds, and as soon as they are asked to pay the costs they take advantage of the Bankruptcy Act ; and though we get decisions in our favour we have to pay our costs, and we can get nothing out of them. It is, however, only by vigorously proceeding against infringers, and insisting upon the delivery up of the infringing instruments wherever found, that it is possible to prevent the wholesale infringement of the Company's patents, and this necessarily involves a considerable expenditure. We must look upon this as a necessary charge to protect our own revenue—like the expenses of the coastguard to prevent smuggling. I understand that we have recovered more than 2,000 infringing instruments from various people, and all of these have been delivered up to our Company. The purchasers lose both the instrument and their purchase-money as a penalty for dealing with those persons who pretended that they were not infringements on our patents. We think we have been able to show you a good account, but if we are to go on and prosper I must say again that the shareholders must assist in helping forward the business, and not only bring in more subscribers to our system, but enable us to put them on as quickly as possible by assisting us to get way-leaves, because although very often we can get subscribers, it takes us a long time to connect them. Every shareholder has some influence over other persons, and a kind word in those cases would very often get us a way-leave which we should otherwise not obtain. Sometimes, I am sorry to say, we have had to ask for some forbearance from our subscribers, who are not satisfied always with the quickness with which the system is worked, and they have recently been kept a long time before getting connected with one another. But I must ask you to remember that during the last three or four months we have completely renewed the interior of two of our largest exchanges, and also one of the great Trunk exchanges ; and all this has had to be done at night time, or during the day time when we cannot cease our business for a single moment. You can therefore imagine the great difficulties we have to surmount. I think, however, that in a month's time we shall be able to show the subscribers a very much improved working of the whole system ; and after that, if it answers, we shall proceed to renew our other exchanges in town and on the same plan. We have got a sort of show now on at two or three of the exchanges—in Queen Victoria-street and Oxford-court—and I wish some of the shareholders would go and get some notion of their property and the way the business is carried on. If subscribers and shareholders would only come and see how the business is done they would be able to estimate for themselves some of the enormous difficulties that have to be met with and overcome in carrying on this telephone system in London. I do not think I have any further remarks to make at present, and therefore I will now move, "That the report and accounts be taken as read, and be received and adopted ; and that a dividend for the half year ended 30th April, 1886, of 9s., less income-tax, for fully paid shares, part paid shares receiving in proportion, be now declared, making a total dividend for the year of 13 per cent. on the paid-up capital of the Company."

The DEPUTY-CHAIRMAN (Mr. J. S. Forbes) formally seconded the motion.

Mr. DONOVAN said the number of subscribers and the private wires, multiplied by 20, showed a discrepancy as compared with the amount stated in the report.

The CHAIRMAN : Do you want to know the amount paid by subscribers to the private wire system ?

Mr. DONOVAN : Including the private wires and the exchange system.

The CHAIRMAN : All the private wires are different prices—all sorts of prices, varying from £5 to £60.

Mr. DONOVAN : That will account for the discrepancy.

The CHAIRMAN : Yes, I think so. Then there are all the £12 wires, which are a good deal taken advantage of for connecting up subscribers with their own houses. Any £20 subscriber may now be connected with his own house, if it is within the metropolitan area, for £12 additional.

Mr. WILLIAM ABBOTT addressed the meeting at some length, and in the course of his remarks said : I think it speaks a great deal for the character of your report that your shareholders upon this occasion receive your remarks without making any comment upon them. It is not my intention to make any adverse criticism on the report, because, if I were so disposed, I must candidly tell you that I could find nothing on which to hang remarks. But, sir, I waited for the issue of this report to see if it was the intention of the Directors to make any movement with regard to the very large dormant asset which you have, and which you retain in your subsidiary shares. I think the time has now arrived when that very important question should be carefully considered. Far be it from me to wish it should be considered by the shareholders in a spirit of hostility to the Board, for that is certainly not my intention—my intentions are quite the reverse ; I wish that it should be considered in the interests of the shareholders, and in the interests of the Company. I lately addressed a letter to the Chairman, suggesting that now was the time when this question should be taken into consideration. It is quite impossible you should keep down your dividend to 13 per cent. This Company is only in it infancy. You have only really scratched the surface of telephone enterprise in London alone, and you certainly have gone very little below the surface in the development of telephone enterprise in the provinces. That being the case, I made a suggestion to the Chairman. I am not going to trouble you with the whole of the letter I addressed to Mr. Brand, but I stated that I saw several advantages in the plan I proposed, one of which was that those £600,000 odd shares of the nominal value of £6. 10s. for every one of your shares should be placed in a trust, the Directors remaining the trustees, and that against those shares they should issue to each shareholder a bonus certificate to bearer of the nominal value of £6. 10s., but of the actual market value of about £4. The reason I made this suggestion was that, in view of the increased dividend which is certain to come to you, it is unfair that those shareholders who have borne all the trials and anxieties with the Directors should not, now that the time has arrived, have taken into consideration such a distribution as I propose, and which I think would not only be feasible, but very acceptable to the members. In this letter I maintain that the new shareholders who come in as fresh partners have no right to participate in those shares. They come in as partners on the dividend-earning power of the Company, and not to share in the accumulations which by the foresight of the Board have been created in your interests alone. Now I say in my letter : "The issue of these 'bonus trust certificates' in such proportion as may be decided upon would not really reduce the value of the original share, as there is every prospect that with the increasing business the dividend will now steadily augment." And now comes the most important point : "The permanent augmentation in value of both classes of shares by the creation of a new proprietary, whose interests would be largely identified in the development of the subsidiary companies." You attached in your opening address great value to that very point. You referred to the widening out of the proprietary, and to the widening out of the subscribers, which bring in an increased revenue to the parent company. I maintain the plan I propose would have that effect—it would largely augment the interest people take in telephone enterprise, which is hardly known and understood. I went down to Wales the other day and there they hardly believe in the possibility of talking at a short distance. If this was thoroughly understood the value to the parent company would be largely increased. Well, another point is, "That the directors being also the trustees, the control of the sub-companies does not pass away from them." That is most important. It would be a very serious matter if these shares of the sub-companies passed into other hands, and if the directors had not the full control of the sub-companies. No doubt Mr. Brand will say that the sub-companies are only in their infancy, and that we should be parting with a valuable asset which has not been properly developed. I will reply to that, "Perfectly true; but while you are going on hatching these golden eggs surely the shareholders may have them in another form. There can be no objection to them having them in the shape of bonus certificates." Now, sir, it may be said, "Why does Mr. Abbott come in and disturb our quiet, peaceful, happy state?" Some of those whom I represent—and I represent shareholders holding 2,000 shares—have an idea that they may as well enjoy the fruit which they have sown during their lifetime, and not leave the enjoyment to posterity. An intelligent countryman of my own, who was not a Home Ruler, said, "Posterity has done nothing for me," and why should we not have the benefit of these subsidiary shares before we throw off this mortal coil? I see that Mr. Forbes is present, and Mr. Forbes knows that exactly a similar thing was done, or is about to be done, in the Metropolitan Railway, who have a certain amount of surplus land in the capital account. There it remained, and its value was not shown in the stock, but a resolution of the shareholders allowed the directors to separate the land from the stock. And what is the result? A considerable advance in the value of the stock. I do not see why you should not enjoy the benefit of a considerable advance in your property, and the divison I propose would have that effect. I am not advocating this for market purposes. You alluded just now to the serious difficulties you have had to surmount. It is perfectly true, and I do believe that you have surmounted them, and I believe now the energies of yourself and the staff will be set free for the development of the property, which, as I say, is only in its infancy. He afterwards referred in warm terms to the services of the Chairman, and alluded to an interesting visit which he had paid to the works, over which he had been conducted by Mr. Morgan (the Managing Director). He trusted that the Chairman in his reply would state whether his (Mr. Abbott's) proposal would have the support or the opposition of the Board.

MR. E. H. GALSWORTHY said he was not convinced by Mr. Abbott's argument in favour of the scheme which he had propounded, and he demurred altogether to the suggestion that the Chairman should state off-hand whether it would receive the support or the opposition of the Board. On the other hand, he considered Mr. Abbott's remarks worthy of grave consideration, and for his own part he would have perfect confidence in the decision at which the Directors might arrive, seeing how they had managed the affairs of the Company up to the present. Mr. Abbott had given as the reason for his proposal that if the shares were divided as he proposed their price would advance. He thought that that was a matter of opinion. He found that the revenue account had this time benefited by the dividends on the subsidiary shares to the extent of £11,200. If Mr. Abbott's plan were adopted the revenue account would lose that, and the dividend would suffer ; and if the dividend were less, the market value of the shares would be depreciated. If he could have the benefit of the same dividend as well as the benefit of the subsidiary shares in the manner foreshadowed, he would be glad, but he did not see how that could be done. He desired to know whether anything fresh had been done in the way of legislation, remarking that the Company had not its own way, and that what it had was very much on sufferance and by the leniency of other people. He certainly could not agree that the anxieties of the Board were over [the Chairman : Hear, hear]. He wished to know, as regards the working expenses, whether provision had been made for depreciation, and whether the expenditure had been taken this year on the same basis as in the preceding year.

The CHAIRMAN, in reply, said that with regard to the progress of the subsidiary companies, they were last year asked for some information on the point ; but there was some difficulty in bringing into the accounts of

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the Company the accounts of the other companies. The National Company had a gross income of £80,000, the Lancashire and Cheshire Company £73,800, the Northern District Company £4,200, the Irish Company £9,813, the Western Counties Company £10,600. and the South of England Company—which was the last established—£8,400. They had done nothing with regard to legislation. No one had said anything to them, and they had not said anything to anybody. Of course the Directors would do their best with regard to legislation. He quite agreed with what Mr. Galsworthy had said, and no one knew better than that gentleman the difficulties against which the Company had to contend. He by no means expected to have a bed of roses in the future, certainly not in the immediate future. As to the question about depreciation, they had allowed £6,500 on that head, besides the maintenance which was constantly going on. He did not know that he could say any more than that. With regard to the remarks of Mr. Abbott, he did not take exception to anything that that gentleman had said. He might have thought that Mr. Galsworthy, from his remarks, had been present at the interviews which he (the Chairman) had had with Mr. Abbott. The matter was one that would require very careful consideration on the part of the Directors, and he was not quite sure that Mr. Abbott had acted rightly in putting his proposal in his circular. Mr. Abbott had said that he did not think it possible that anyone could accuse him of approaching the Directors in a hostile feeling. He (the Chairman) did not think it possible that Mr. Abbott or any other man could do that. Like Mr. Galsworthy, he (the Chairman) did not know much about Stock Exchange matters, but the principle on which the Directors had gone had been to raise the price of the shares by paying good dividends. He wanted Mr. Abbott, in advocating all the things that appeared to him to be so good in their Company, not to pile it up too much, as they were surrounded by all sorts of people who might take advantage of it. It was the bounden duty of the Directors to think of everything that was to the good of the Company, and if Mr. Abbott at any time would like to come and see him he would tell him if he was getting any nearer to Mr. Abbott's way of thinking. As he had already told Mr. Abbott, "If I can pay £5 dividend, and the price of the share is £100, and you can show me how to transform that £100 into £120, and do no harm to any one, I shall be very pleased, and so will the other Directors, as we all hold a considerable stake in the Company." They had not made up their minds in the matter, but as he had intimated already, whatever was good for the shareholders was good for the Directors. He put the resolution, and it was carried.

On the motion of the CHAIRMAN, seconded by the DEPUTY-CHAIRMAN, the election, by the Directors, of Mr. Dwyer Gray, M.P., as a member of the Board, was confirmed.

Mr. Dillwyn Parish and Mr. W. C. Quilter, M.P., the retiring Directors, were re-elected, as were also the auditors, Messrs. Quilter, Ball, and Co. and Messrs. Price, Waterhouse, and Co.

Mr. W. ABBOTT then proposed, and Mr. GALSWORTHY seconded, a vote of thanks to the Chairman and Directors, Mr. Galsworthy expressing the hope that some day the shareholders would place on some permanent record their appreciation of the services of Mr. Brand, who, he thought, had the United Telephone Company on the brain.

The CHAIRMAN, in acknowledging the vote, assured them that the Directors had all worked hard, and he was only very glad to think that their efforts had had such good results.

The meeting then separated.

West African Telegraph Company (Limited).

The first ordinary general meeting of this Company was held at the offices, 98, Cannon-street, on Friday, the 2nd inst., Sir Fredk. J. Goldsmid in the chair.

The SECRETARY (Mr. R. N. Moir) having read the notice calling the meeting,

The CHAIRMAN said that the statement of accounts submitted was of a *pro forma* character—to meet the requirements of the Company's Articles of Association—and the items did not appear to require explanation. The prospectus of the Company was not issued until the 8th of April last, but a considerable amount of work had been done previously to that date. In order to comply with the conditions of the concessions, it was necessary that the first sections of the cable should be completed within six months. Accordingly by the 5th December, the cables between Senegal, Bolama, Bissao, and Conakry were laid, and in the same month opened to the public. This fact was practically important, because from this particular period the Company was entitled to such portions of the Portuguese guarantee as might be applicable to those sections, and also to the French subsidy for Conakry. Since the issue of the prospectus much progress had been made in carrying out the work contemplated. The contractors' cable steamers, "Dacia" and "Buccaneer" left the Thames on the 22nd May, and information had already been received informing the Directors that communication had been established with Bathurst, and a station opened there. They had also pleasure in reporting that the cable between Conakry and Sierra Leone was successfully laid and communication opened on the 30th ult. Up to the present time the Directors had every reason to be satisfied with the manner in which the contractors were fulfilling their contract, and it was expected that the Company's system would be completed to St. Paul de Loanda by the middle of October, or some two months before the period required by their Portuguese and French concessions. The Directors had also to report that since the issue of the prospectus they had entered into a working agreement with the African Direct Telegraph Company, which gave very favourable transit rates to the West African Company, and the permission to land at the English colonies enabled this Company to compete with the African Direct Company on equal terms for the traffic of those stations. He concluded by moving the adoption of the accounts to the 31st December as presented, and the motion having been seconded, it was carried unanimously.

Eastern Telegraph Company.

Report and accounts of the Directors for the half year ended 31st March, 1886, to be presented to the twenty-eighth half-yearly ordinary general meeting, to be held at Winchester House, 50, Old Broad-street, E.C., on Thursday, the 15th inst., at one o'clock.

The revenue for the period amounted to £341,405. 8s. 10d., from which are deducted £92,244. 15s. 10d. for the ordinary expenses, and £41,637 3s. 2d. for expenditure relating to repairs and renewals of cables, &c., during the half year. After providing £3,940. 4s. 11d. for income tax, there remains a balance of £203,583. 4s. 11d. to which is added £32,549 12s. 5d. brought from the preceding half year, making a total available balance of £236,132. 17s. 4d. From this balance there has been paid—

Interest on debentures and debenture stock	£27,756	17	10
Dividend on Preference shares	20,296	16	10
An interim dividend of 1¼ per cent. on the ordinary shares	47,500	0	0
	£95,553	14	8

leaving a balance of £140,579. 2s. 8d., from which £70,000 has been carried to general reserve. The Directors now recommend the declaration of a final dividend for the year ended 31st March, 1886, of 2s. 6d. per share and a bonus of 1s. per share, amounting to £66,500, both payable on the 15th inst., making, with the three previous payments on account, a total distribution of 12s. per share, or 6 per cent. for the year on the ordinary shares. The balance of £4,079 2s. 8d. shown at the foot of the revenue account is proposed to be carried forward to the next half year. The revenue includes £9,750 dividend for the half year upon the Company's shares in the Eastern and South African Telegraph Company. Also £2,600 net receipts for the same period on the shares of the Black Sea Telegraph Company belonging to this Company. The receipts of this half year compare with those of a period when the income was abnormally increased by the telegrams resulting from the military operations in the East, and they have also been adversely affected by the continued commercial depression. The reductions in the tariffs agreed to at the International Telegraph Conference in Berlin in 1885 came into operation on the 1st inst., but it is as yet too early to form an estimate of the probable effect on the Company's revenue. The several sections of the Company's cables and the land lines in connection therewith are in good working order, with the exception of the Direct Lisbon cable, which is now under repair by the Company's ss. "Electra." Since the last general meeting the arrangements with Her Majesty's Government for establishing telegraphic communication with the British possessions on the West Coast of Africa have been completed, and the work is now being carried out by the African Direct Telegraph Company. The subscription by this Company of £75,000, being one-third of the share capital of the African Direct Telegraph Company, approved by the last meeting of shareholders, has been effected by the issue of a similar amount of 4 per cent. debenture stock of this Company.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. JULY 7.		BUSINESS DONE WEEK ENDING JULY 7. Highest.	Lowest.
Anglo-American	33,	34	33	—
Do. Preferred	55,	56	56	55½
Do. Deferred	11½	11⅝	11⅝	11½
Brazilian Submarine	10⅛	10⅜	10⅜	10⅛ x.d.
Cuba	10⅛,	11	10⅞	10⅞
Do. Preference	18¼,	19½	—	—
Direct Spanish	1½,	2	—	—
Do. Preference	9,	10	—	—
Direct United States Cable	9¼,	9⅜	9½	9½
Eastern Telegraph	10⅞,	11¼	11 1-16	10⅞
Do. 6 per Cent. Preference	14¼,	14½	14 9-16	14¼
Do. 5 per Cent. Debentures, 1899	106,	109	—	—
Eastern Extension	12⅜,	12⅝	12½	12¼
German Union	9¼,	9½	—	—
Globe Telegraph and Trust	6⅜,	6½	6⅝	6 9-16
Do. Preference	13½,	13⅝	13¾	13¾
Great Northern	12,	12⅛	12⅜	12¼ x d.
Indo-European	34½,	35½	—	—
Reuter's	6,	6½	—	—
Submarine	200,	210	208½	208
West India and Panama	⅛,	⅜	11-16	—
Do. 1st Preference	8¼,	8⅜	8½	—
Western Brazilian	6⅜,	6¾	7½	6⅜
Western Union 7 per Cent. 1st Mortgage	118,	122	—	—
Do. 6 per Cent. Sterling Bonds	103,	107	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	13-16	15-16	⅞	13-16
Oriental	3-16	5-16	3-16	—
United Telephone	14,	14½	14½	14½

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	2⅛,	2¼	2¼	—
Do. (fully paid)	4,	4½	—	—
Swan	1⅜,	1⅜	—	—
Maxim-Weston	3-16	5-16	¼	—

MISCELLANEOUS.

Telegraph Construction	39½	40½	40½	40
India Rubber, Gutta Percha, and Telegraph Works	22½	23½	23⅝	23

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NOTES.

CABLE INTERRUPTION.—The cable between Antofagasta and Caldera is interrupted.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 9th inst. amounted to £3,136.

THE WEST COAST OF AMERICA TELEGRAPH COMPANY.—The gross earnings of this company for the month ending June 30th were £3,200.

TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY. A half-yearly general meeting of this company will be held at 38, Old Broad-street, E.C., on Tuesday, the 20th inst., at 1 o'clock.

BRIDGE BUILDING BY THE ELECTRIC LIGHT.—The cylinders of the bridge of six 130ft. spans, over the Beypore River, on the Beypore-Calicut extension, are being sunk at night with the aid of the electric light.

PERSONAL.—In recognition of the great advance exhibited in Mr. Lucius J. Phelps's method of communicating telegraphically with moving trains, the Franklin Institute has awarded to that gentleman the John Scott medal and prize.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 9th inst., were £2,451, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

TELEPHONIC EXTENSION.—The Northern District Telephone Company have received permission from the Durham and Chester-le-Street Highway Board to erect 50 telephone poles on the roads between the top of Crossgate, Durham, and Aldin Grange.

PERSONAL.—Mr. Hugh Watt, M.P., managing-director of the Maxim-Weston Company, has had conferred upon him by the President the Grand Cross of the Order of Simon Bolivar, for distinguished commercial services in connection with the United States of Venezuela.

A HEAVY FINE.—The New York jury, in the action brought by the Receiver of the Bankers' and Merchants' Telegraph Company against the Western Union Railroad Company for cutting the wires of the former, have given a verdict against the Western Union for 240,000 dollars.

OBITUARY.—David van Nostrand, the well-known American publisher, died at his residence in West Twentieth-street, New York, on June 14th last. The cause of death was severe dyspepsia. Mr. Van Nostrand was the most extensive publisher and dealer in electrical works in America.

POSTAL TELEGRAPH REVENUE.—The exchequer returns for the period from April 1st to July 10th of the present year show that the total receipts from the Telegraph Service were £425,000, a falling off of £20,000 as compared with the corresponding period of 1885, when the 1s. tariff prevailed.

HONOUR TO ELECTRICIANS.—M. Eugène Sartioux, chief of the telegraph service of the Northern Railway Company of France, and M. Henry Vivarez, civil engineer of mines, and an old and distinguished student of the Ecole Polytechnique, have recently been made knights of the Legion of Honour.

BRUSH ELECTRIC LIGHT CORPORATION.—The Brush Company is giving notice by circular that they are prepared to indemnify all users of their incandescent electric lamp, known as the "Victoria" lamp, against proceedings for any alleged infringement in those lamps of the patent rights of other manufacturers.

ACCIDENTS FROM LIGHTNING.—In a lecture given by Captain Holthof before the Physical Society of Frankfort-on-the-Main, the lecturer pointed out that accidents by lightning stroke had become more frequent since the trees had been so largely cut down, and the houses fitted up with electrical wires, gas fittings, and metal roofs.

ELECTRIC LIGHT COMPANIES.—The shareholders of some of the electric light companies in America are better off than their colleagues here. We notice, for example, that the Hartford Electric Light Company, using the Thomson-Houston system, has been paying a dividend of 1½ per cent. regularly each quarter for the last year and a half.

ELECTRIC LIGHTING AT KETTERING.—Messrs E. L. Berry and Co., of Oxenden-street, W., made a successful installation of the electric light at the Corn Exchange, Kettering, on July 4th and 5th, and also at a *fête* held in the Rectory Grounds on the 6th, 7th, and 8th inst. Messrs. Goolden and Trotter's Tallenta arc lamps were used, together with about eighty coloured incandescent lamps.

SIMPLICITY OF WORKING ELECTRIC TRAMWAYS.—Mr. Holroyd Smith, consulting engineer to the Blackpool Electric Tramway, writing to a local newspaper, says :—"I am thankful to say that my professional services are seldom required, for the problems I had to solve have been reduced to such simplicity that others previously unacquainted with mechanical science can now undertake the arrangements."

COLONIAL TELEGRAPHS.—Conformably with our announcement in last week's edition, Mr. James Sivewright, C.M.G., read a paper on Thursday afternoon last at the Indian and Colonial Exhibition on the subject of our colonial telegraph system. The same paper, we understand, will with certain additions be read soon before the Society of Arts, when we hope to be able to furnish our readers with a full report of it.

INDIA RUBBER, GUTTA PERCHA, AND TELEGRAPH WORKS COMPANY.—A half-yearly general meeting of this company will be held at the Cannon-street Hotel on Tuesday, the 20th inst., at 12 o'clock noon, for the purpose of obtaining the sanction of the shareholders to the payment of an interim dividend of 5 per cent., or 10s. per share, free of income-tax. The directors give notice that the share register will be closed from the 13th to the 21st inst, both days included.

DIRECT UNITED STATES CABLE COMPANY.—The Board of Directors of this Company has resolved to recommend a final dividend of 2s. per share, free of income-tax, such dividend to be payable on and after the 24th inst., making, with the interim dividends already paid, 2¾ per cent. for the year ending 30th June last, carrying forward £3,050. 19s. 3d., after having increased the reserve fund to £325,000. The company give notice that the transfer books will be closed from the 9th to the 23rd inst., both days inclusive.

BRANDING BY ELECTRICITY.—It is said that the Chemical Electric Light and Power Company of Boston have received an order for their Volta-Pavia battery to be put to a new and unique use. The proprietor of an extensive sheep ranche in Montana intends using the battery for maintaining a platinum wire at white heat, which will be used for branding the members of his flock on the nose. The operation is quickly performed, and comparatively painless when the former plan of using a branding iron is considered. An 8-cell battery will be required.

THE ELECTRIC LIGHT AT HANLEY.—The corporation of Hanley are just now experimenting with the electric light, with a view to its adoption for public lighting. So far the majority of the members of the council have expressed unqualified approval of the new system of illumination. The small installation, which is purely arc light, of course has been

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put up in the covered market, and there is reason to believe that, as the result of the experiments, a contract will be entered into for permanently lighting the town by electricity.

HOME RULE IN FRANCE.—M. Granet, Minister of Posts and Telegraphs, has concluded a contract with the Messageries Maritimes Company, by the terms of which the company's present steamship services are to be modified, and additional services are to be established. It is specially stipulated that the company's vessels shall be of French construction and use French coal, and also that the transport tariff shall no longer benefit British products to the detriment of French merchandise. The new contract will come into force at the end of 1888.

AN EYE TO THE FUTURE.—In view of the celebration of Her Majesty's jubilee, the gas companies are showing unusual activity, and are industriously circulating, for the information of all those whom it may concern, certain hints and instructions on the subject of outdoor illuminations. This gratuitous and timely advice, it is needless to say, conclusively proves, from the gas companies' point of view, the superiority and economy of coal gas for these purposes as compared with electricity. Whether the public will be of the same opinion the future alone will determine.

ILLUMINATING WATER BY ELECTRICITY.—At the new Cirque Nautique in Paris there is just now an aquatic performance of a very novel character. After the conclusion of the ordinary gymnastic and riding entertainment, the carpet is removed from the floor of the ring, and the latter entirely submerged. A circular basin is thereby produced, and an electric arc lamp illuminates the water from below. The swimming performers appear like mermen and mermaids in the translucent depths of the sea. The installation throughout the building is a very fine one, including both arc and incandescent lamps, the *lampe soleil*, or sun lamp, especially producing a most beautiful effect.

THE ELECTRIC LIGHT AT NORWICH.—The offices of the *Eastern Daily Press* have recently been lighted by the electric light. The installation, which has been effected by the well-known local firm, Messrs. Paris and Scott, consists of a hundred lights conveniently arranged throughout the building, the current being supplied by one of their patented four-pole machines. It is needless to say that the compositors and others whom the exigencies of journalism compel to be at work through the greater part of the night appreciate the reduction of heat and the greater purity of the air consequent on the substitution of electricity for gas, not to mention the increased illumination which they acquire by the change.

A NEW CABLE.—The *Echo* of last evening is responsible for the following :—"One link is still wanting to complete the chain of British rail and cable round the world. No cable has yet been laid from British Columbia to our Eastern possessions. It is now announced, however, that a strong syndicate has been formed for joining Vancouver and Hong Kong by cable, and Mr. Sandford Fleming is now on his way to London from Montreal to confer with the Home Government and the colonial agents as to the amount of annual subsidy they would guarantee. It is also proposed to lay a cable from Vancouver to Sydney, but as the distance to Hong Kong is considerably less, being only 6,180 miles, this work will doubtless be undertaken first."

NEW ZEALAND.—The Town Council of Queensland, New Zealand, have rejected an offer to supply the town with gas, thinking that more effectual means of lighting the town by electricity might be devised before long. That electric lighting is making its way in New Zealand is pretty certain. We notice that a temporary installation was put up at an entertainment to obtain funds for the hospital at Skippers Reefs. The correspondent writes:—"The hall was tastefully decorated and brilliantly lighted up with the famous electric light. The attendance was something to be wondered at for these parts, and the catering excellent, so that to call it a great success is very mild praise ; and as to the financial aspect, the result ought to make the Wakatipu Hospital Committee smile for the next twelve months."

NEW PRIMARY BATTERY.—Dr. S. T. Stein, of Frankfort-on-the-Main, considers that the best battery for curative purposes would be one in which the exciting liquid does not evaporate, so that no salts are formed on the upper edge of the jar. Many attempts have been made to secure this desideratum, but hitherto without success. Dr. Stein has, however, conceived the idea of adding gelatine to manganese batteries, finally adopting a mixture of gelatine, glycerine, sal ammoniac, and salicylic acid, the electrodes consisting of a carbon cylinder, with bioxide of manganese for the positive pole, and a zinc pencil for the negative pole. The internal resistance is, according to size, from $\frac{1}{2}$ to $\frac{1}{8}$ ohm, and the E.M.F. from 1 to 1·085 volt. The chemical reactions of the new battery are the same as in the Leclanché.

A USEFUL INVENTION. — An ingenious apparatus has recently been invented by M. Helie which ought to command some attention on the part of railway companies. This is a simple mechanical appliance which apprises the guard in charge of a train in motion whenever a carriage door is opened, by letting on an electric current which sounds an alarm bell, when of course he can immediately communicate with the driver and bring the train to a stop. In these days, when crimes are not infrequent on railways in all parts of the world, the universal adoption of such an arrangement would afford an additional sense of security to the traveller, for the would-be perpetrators of such deeds as those of Müller and Lefroy would then have to think twice before indulging in their merciless work of rapine and murder.

TODMORDEN AND THE ELECTRIC LIGHT.—There is at last some hope of the inhabitants of Todmorden being served with an installation of the electric light. It would appear to have been the custom of the Local Board to appoint annually an electric lighting committee, whose duty was supposed to be to take some practical steps towards meeting the wishes of the ratepayers in the matter of public lighting by electricity. Up to the present time, however, those committees seem to have folded their hands and gone to sleep. We are glad to see that the gentlemen who have been last delegated to look after this important department of the local polity have taken the initiative step of inviting the Victoria Electric Lighting Company to furnish the Board with some information as to its mode and cost of lighting. It is to be hoped that, as the result of the negotiations, the electric light will soon be permanently installed in the streets of Todmorden.

ELECTRIC RAILROADS.—We have received from the Daft Electric Light Company a small pamphlet describing the Daft Electric railways as used at Baltimore. The report of the manager of the railway company states that from September, 1884, to May 20, 1885, using three cars with horses, a total number of 158,684 passengers was carried at a cost per passenger of 3·01 cents. From September, 1885, to May 20, 1886, that is during the corresponding period twelve months later, working two cars with Daft electromotors at a speed almost double that when two horses were used, the total number of passengers carried was 188,591, at a cost per passenger of 1·66 cent. The total cost per day was 12 dollars, as against 18 dollars

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per day for the horse. The length of road is nearly two miles, or more exactly 10,080 feet. The total weight of the train with 50 passengers is about 17,250lbs.; the usual service of the motors is about 73 miles per day.

CRYSTAL PALACE.—The Gülcher Company have extended the electric lighting to the illumination of the grounds of the Crystal Palace, which gives great satisfaction. The installation consists of eighteen arc lamps, seventeen of 2,000 candle-power and one of 3,000 candle-power. Six of 2,000 candle-power are used for lighting the Rosary, and four of 2,000 candle-power in the band stand. The remaining seven, of 2,000 candle-power, are placed in different positions for the general illumination of the grounds, the 3,000 candle-power lamp being placed on a high pole for lighting the large centre lawn. The general effect is extremely pleasing. The lamps are driven by two No. 4 Gülcher dynamos, the current being taken to a double switch-board, which is arranged so that in case of accident to any dynamo the whole of the lamps may be worked from the one dynamo. The machines are driven by two of Messrs. Ransomes' 10 horse-power portable engines.

TEMPORARY LIGHTING.—The Gülcher Company are lighting the new building belonging to Messrs. Allen and Sons, builders, for the Temperance Mission now being held at Kilburn. The installation consists of forty 20 candle-power incandescent lamps for the illumination of the large room where meetings are held nightly. The incandescent lamps are suspended from the ceiling by flexible pendants, which carry an ornamental shade, and the general effect is extremely pleasing, and great satisfaction has been expressed by the members. In addition to the incandescent lamps, three arc lamps of 2,000 candle-power are employed for the illumination of the Palmerston-road, and the entrance to the building. The current for driving the installation is generated by a No. 4 Gülcher dynamo machine, and the motive power is obtained from Messrs. Allen and Son's saw mill engine. Only two days' notice were given to carry out the installation, and therefore its successful accomplishment reflects great credit upon the contractors.

INTERNATIONAL WIRE GAUGE.—Our contemporary *The Electrical World* is giving space for a correspondence suggesting the advisability of an international wire gauge. We should strongly support any suggestions in this direction, as we think that the best interests of commerce are furthered when in ordering every one can quote similarly. It may be that it is in the interest of one particular firm, or the interest of a few firms, to support different gauges, in that a firm which has made a reputation for wire would prefer to keep all its customers. We are quite sure that the business of a firm does not ultimately depend upon the minute difference which it makes in its sizes, but in the quality of the material it sends to its customers, and to the method adopted in treating with those customers We believe the suggestion of an international wire gauge is on a par with suggestions which recommend international gauges for screws, international coinage, &c. It might be of some assistance to our American brethren if expressions of opinion were given on this side of the Atlantic.

PHOTOMETRY.—The first portion of what would seem to be an excellent article upon "Photometric Measurements, and their Relation to the Efficiency of Incandescent Lamps" appears in the issue of the *Electrical World* for July 3, just received. The article is written by Mr. A. P. Wright, who, at the commencement of the article, says:—"To compare the relative efficiency of incandescent lamps it is not merely sufficient that the electrical measurements should be made with accuracy, but the measurement also of their illuminative intensity should be estimated with precision. While great care is usually taken to insure the accuracy of the electrical measurements, the photometric observations are frequently as crude as the instruments with which they are too often made. Again, while these measurements, when carefully conducted with a good photometer, give results which show the relative illumination of lamps having filaments of the same configuration and dimensions, they in almost all instances fail in showing either the true mean illumination or the relative lighting value of filaments of varying form, length, and section."

ELECTRIC GONGS ON GERMAN RAILROADS.—Tabulated statements of the number of electric gongs by which the approach of the train is announced from point to point, especially at crossings, on German railroads, make, says the *Railroad Gazette*, the mean distance apart of these gongs 950 metres, or 3,116ft., and on Austrian railroads 1·04 kilometres, or 3,411ft. These gongs are arranged on a circuit between two stations and are operated analogously to the block system; that is, station A announces to B that a train is ready to start, whereupon, if B knows of no obstacle, he acknowledges the signal by giving "all right," and A then presses the key which causes the gongs between A and B to strike. The German roads are now generally arranged so that this system is a perfect block, telegraph stations being inserted where necessary between the stopping stations; but on the light traffic roads B is allowed to give "all right" without having received the last train that went into the block. It will be perceived that even where not used as a block system, and apart from the warning given to trackmen and crossing tenders, these bells, which can be heard nearly, if not quite, from one end to another, are a considerable aid to safe working, since a train in the block always gets warning of another train entering behind it. These bells are used by combinations of blows to give a variety of information, such as "Train toward A!" "Send over engine!" "Stop all trains!" "Set your watches—noon!" "Train backing up on wrong track!"

INTERNATIONAL SOCIETY OF ELECTRICIANS.—At last this society seems to have got a local habitation and a name. An extraordinary general meeting was held this week in Paris for the purpose of giving effect to a generally-expressed desire on the part of the gentlemen forming the association, which hitherto has been only a nominal one, that they should have a corporate *locus standi*. The effect of this will, of course, be to increase the society's powers of action and usefulness, and to enable it to carry out those projects which have already been formed by its irresponsible members. In the course of the sitting the President announced that the difficulties which have militated against the establishment of a central electrical laboratory—a project which has been in a state of incubation since the Exhibition of 1881—have been almost overcome. Thanks to the good offices of the present Minister of Ports and Telegraphs, the stupid obstacles which were put in their way by the previous administration, &c., had all but disappeared, and the sum of 325,000 francs which had been at their disposal for more than four years will now be put to the uses for which it was originally destined. M. Maurice Lœwy has, indeed, gone so far as to inform his colleagues that 31,000 francs will be immediately spent in the name of the society in the purchase of its first apparatus. The Executive Committee, in their desire to give to the Minister an earnest of their gratitude for his courtesy and kindness, have placed the society under his immediate protec-

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tion and patronage by their intention of holding their reunions henceforward at the offices of his department.

FARBAKY AND SCHENEK'S ACCUMULATOR.—In this new secondary battery the lead plates are covered in a special manner without being subjected to great pressure, and with an active substance specially prepared, the object being to obtain a more energetic and constant action, and to prevent the active substance from escaping at the interstices of the plates. The thickness of the plates and the nature of their "making" differ for the positive and negative electrode, the former being from 10 to 12 millimetres thick, and the latter from 6 to 8 millimetres. The active substance for the negative plates consists of 95 parts by weight of well powdered litharge, without copper, and 5 parts of pumicestone, in grains of 1 to 1½ millimetres, for rendering the mass less dense and more porous. This condition is very important, because it facilitates the escape of the dilute sulphuric acid, and consequently the working of the accumulator. The two substances are intimately mixed in the open air, or in a well-ventilated room, and then diluted sulphuric acid (at 25 per cent.), free from arsenic, is added to form a granular mass, rather damp to the touch. The active substance for the positive plates consists of 95 parts by weight of litharge, 95 of red lead, and 10 parts of coke broken into pieces of 1 to 1½ millimetres. The addition of the coke is for rendering the substance more conductive, and also less dense, so as to be more permeable by the sulphuric acid solution. The active substances are spread by a galvanised iron spatula over both sides of the positive and negative plates (which are cast or pressed with interstices) in such a way as to project about 3 or 4 millimetres beyond the surface of the plates. They are then beaten with a flat brass rule, until moisture ceases to exude. That portion which projects beyond the plate is then pared off with a flat knife, and the "made" plate allowed to dry for two or three days, after which they are immersed three separate times in diluted sulphuric acid, and dried after each immersion, and then left in the bath for 10 or 12 hours, and then again dried, when the surface solidifies.

TELEGRAPHIC REFORM.—In answer to some comments in *The Times* on the paper on "Telegraph Reform," recently read by him before the Congress of Chambers of Commerce at South Kensington, Sir James Anderson sends the following letter to the Editor:—"Sir: In one of your leading articles this day I am assumed to have threatened to still further raise the telegraph tariffs. I should feel obliged if you would allow me to say that nothing is further from my thoughts, nor do I know any one who is contemplating such a change, unless it may be that if the present unremunerative Atlantic tariff should fail to develop a paying traffic then something more than 6d. per word to America may have to be charged. In my paper I tried to give several illustrations of plans by which tariffs might be very much reduced. The first and only illustration noticed in your leader showed that if the Government and colonies interested would risk the loss of £1,000,000 per annum for a few years the tariffs to India, Australia, the Cape, South America, &c., might be reduced one-half—that to America and Egypt to be 1s. per word, and I give it now as my individual opinion that this amount estimated for the first year at one million would be a diminishing quantity and cease altogether within a very few years. Private companies cannot in justice to their shareholders make this certain loss over a number of years. I next called attention to the abuse of code by compilers making syllabic combinations to look like words—not satisfied with the eight languages authorised by the Telegraph Convention, and which are said to give 150,000 telegraph words to which we make no objection. I think we should not have the trouble of rejecting illegitimate words, and that sooner or later codes so compiled will be found to be useless, or if commerce will have them the telegraphic conferences of the future may have to consider a letter tariff. The next point of my paper said all that I think can be usefully said as to the neutralisation of cables, their protection in time of war, and the principles which should govern the extension of submarine telegraphy. I did not make any proposition, but said what I could in the brief space of time allowed—viz., twenty minutes—upon the points named by the Chamber of Commerce with the object of opening a full discussion; and, when replying, I ventured to say in effect that this comparatively new force, by which we can in a few hours communicate with the remotest parts of this Empire and the world, will have as much to do with practical federation as the post or steamships. A really great step would be gained in the interests of commerce if the cost of telegraphing could be reduced to an amount of relatively small importance."

CHICAGO.—The following, from our American contemporary and namesake, will show that our cousins are in earnest about overhead wires. We shall be surprised if the action at Chicago is not speedily followed by all the most important cities in America:—"The streets of Chicago are beginning to change in appearance—for the better. The poles and lines are disappearing quite rapidly. The city's wires have been gradually taken in and sent below, until the south side lines, comprising some thirty-five miles of city wires, have disappeared from the lake to the south branch, and from the river to Van Buren-street; and there was not a street in that entire district that had not one or more fire alarm, police, or other city wires. The Western Union people have removed the poles on Lasalle, from Washington to Jackson, on the west side of the street. These were 55ft. high, and were so thickly strung with line wires that they fairly cast a shadow upon the walk. A heavy line of poles on the east of State-street has been removed. To the north of the office at Lasalle and Washington the company will lay a conduit pipe, and reach the tunnel, when the poles along this route will disappear. In short, the Western Union will very soon clean up through all streets in the south division north of 12th Street. The largest poles in the city were those of the Mutual Union Company, from 12th Street, running to the corner of Lasalle and Washington. These ranged from 55 to 90ft., and are all down. The Baltimore and Ohio are preparing to remove everything north of Harrison-street in a few days. The telephone company has arranged to put its wires underground on the following routes at once:—Starting at Calhoun-place on Lasalle, north to Washington, east to Dearborn, south to Jackson, and east to the Alley, south on the Alley to 20th Street, east to the Alley near Michagan-avenue, and south to 22nd Street. This will pretty much clean up the Telephone Company's wires on the south side. On the west side, commencing at Green-street on Madison, the pole lines will be removed to Ashland-avenue; thence north to the Alley, which will greatly relieve that portion of the city. The Mutual Union has also made arrangements for conduits on Lasalle from Washington to Lake, and along this latter street from Fifth-avenue to Michigan-avenue, with lateral crossings north of Randolph, west of Dearborn, and east of Michigan-avenue. To an old resident the aspect of the business portion of the city is, to say the least, peculiar. The streets look wider, the view is less interrupted, and it really does appear lighter, and, while it is claimed by some that the place is stripped of some of its city characteristics, it is hardly to be believed that the day is approaching when a bell ringer will daily call the denizens of the place to come and weed the thoroughfares."

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TRANSMISSION OF POWER.—The *Lake Wakatipu Mail* of May 14th, sent us by a correspondent, gives a long account of an electric installation for the transmission of power at the Phœnix Company's gold mine at Skippers Creek, Upper Shotover, Otago. From this account and our correspondent's notes the following description is obtained :—" Transmission by means of wire ropes, compressed air, and electricity were considered, and after a thorough investigation electricity was the only method that could be economically and profitably employed. When it became publicly known that electricity was to be employed for driving the machinery about the mine, Mr. Bullen (the proprietor) and Mr. Evans were looked upon by many of their friends as misguided enthusiasts. Many mines are lying idle a portion of the year through want of power to crush the quartz and for other purposes. Water power there is in abundance, in most cases within two or three miles, and now that the Phœnix Company have shown that electricity can be successfully applied in utilising distant water powers, we may expect to hear of many other companies following their example. Having decided upon the use of electricity, Mr. Bullen and Mr. Evans discussed the matter over with Mr. Prince (electrician), with the result that Messrs. R. E. Fletcher and Co., electrical engineers and contractors, Dunedin, were instructed to supply and erect the necessary apparatus for working a battery of twenty stamp heads. Messrs. Fletcher and Co. determined to leave nothing undone that would secure the complete success of this, the first instance of the electrical transmission of power, on a practical scale, in the southern hemisphere. The choice of suitable dynamo machines for generating the electric power was not a very difficult matter, but the construction of an 'electric motor' capable of exerting a force of from 20 to 25 horse-power was quite a different thing. Acting under the advice of some of the best experts in the old country, Messrs. Fletcher and Co. decided to use a specially-constructed 'Victoria' dynamo machine as the 'motor,' and two large 'Brush' dynamo machines for the 'generators.' It was by no means an easy matter to get the plant up from Queenstown to the mine, a distance of 26 miles, the last six miles being through the creek, which had to be crossed and recrossed no less than 84 times, the Phœnix Company having to do this at their own risk. After several delays due to accidents Mr. Fletcher finished the work, but was not destined to have all smooth sailing, as several faults developed themselves in the motor and generators, caused through injuries received in transit. The house where the electric generators are placed is situated about two miles up the Lefthand branch of Skippers Creek, and is an iron building, 60ft. by 20ft. It is built at the base of a nearly perpendicular cliff, some 200ft. or more in height. An open ground race half a mile in length brings the water from the creek to the top of the cliff, where an almost perpendicular fall of 180ft. is obtained, the water being conveyed down the face of the cliff by two wrought iron pipes 22in. in diameter at the top, tapering down to 6in. at the bottom. The supply of water from this race is equal to ten heads when at its lowest limit, but much more can be obtained when the creek is in its normal condition. The electric apparatus is only using four or five heads at present, so that there is ample power for future extensions. Two Pelton water wheels drive the generators. These wheels are extremely simple in construction, consisting merely of a cast-iron pulley or fly-wheel six feet in diameter, and six or eight inches in width, having a number of square-shaped buckets fixed around its periphery. A nozzle 2½ inches in diameter throws a powerful jet of water into these buckets, causing the wheel to make about 370 revolutions per minute when working at its full power. Each wheel will exert 50 horse-power if required, but at present they are working at much less. Messrs. A. and G. Price, of the Thames, the makers, claim an efficiency of from 80 to 86 per cent. The shaft of each wheel carries a driving pulley, which drives by means of a belt an intermediate shaft; these shafts in their turn carry the pulleys that drive the generators. The whole of the machinery is secured to heavy timber foundations. The electric generators are two of the well-known Brush 40 lighters. They are driven at a speed of from 700 to 800 revolutions per minute, and generate each a current of 10 amperes, having an electromotive force or pressure of 2,000 volts, which is equal to a little over 26 horse-power, or about 53 for the two machines. The two generators are coupled parallel. The current goes to a switch-board, and an ammeter is in circuit. Link-belting is used. These belts are very strong, but at the same time extremely flexible, and do not, like many ordinary leather belts, stretch unevenly. The current is conveyed from the generating station to the battery house by a No. 8 B.W.G. copper wire (the size of an ordinary fencing wire), and after doing its work there returns by a similar wire to the generating station again. These two wires (nearly three miles in length) are supported on poles in just the same manner as a telegraph or telephone wire is, and are brought over a hill about 800ft. in height. Lightning arresters, similar to those used for telegraphs, are attached to each end of the wires, to protect the generators and motor in case of a storm occurring and the lightning striking one of the poles or wires. The power lost on the 'line' only amounts to 3 horse-power, and could be still further reduced by using wires of larger sectional area. A telephone connects the generator station with the battery house, so that the attendants in charge of the generators and the motor can communicate with each other when necessary. The motor, as already mentioned, is a specially constructed Victoria dynamo machine, and when working under its normal condition makes about 350 revolutions per minute. A pulley on the armature shaft transmits the motion by means of a belt to the cam shaft of the battery. By means of a switch, more or less electricity can be sent through the motor, so that the power exerted can be regulated to a nicety. When the motor is stopped for any purpose, and it is not necessary to stop the generators, the current is switched or cut off from the motor and sent through a long series of coils of iron wire. The energy of the current is thereby used up in heating the iron wire instead of working the motor. The average weight of these stamp heads is eight hundredweight. Not the slightest difficulty is experienced in starting or stopping the battery; it starts very easily, and can, if desired, be stopped almost instantaneously. It has not been found necessary to have any experienced hands to work the plant, there being a man told off in each shift to take charge of the motor and battery, no one else, of course, being allowed to meddle with the apparatus in any way. In conclusion, the success of the whole undertaking (which is unique in its way, as it furnishes a remarkable instance of high-pressure electric power) may be fairly said to have been accomplished—in fact, to use the words of the manager, Mr. F. Evans, who has just spoken to us, 'the machinery is working beautifully, and the power is sufficient at the present time to keep going at least five and probably ten more stamp heads.' The importance of this new application of electric power for the lighting and complete working of an extensive mine like that of the Phœnix, opens up a new era in the economic development of the very valuable and unexhaustible mineral resources of the Wakatipu and other goldfields similarly situated, which are by no means suffering from a want of water power, but rather from the means of transmitting that power hither and thither."

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ALTERNATING AND INDUCED ELECTROMOTIVE FORCES.—II.

BY W. H. SNELL.

Hitherto we have had under consideration the case of an alternating electromotive force, generated by the rotation of a single loop of wire placed in a uniform magnetic field, and we have taken T as the time occupied in one complete revolution. But in the majority of practical machines for producing alternating currents, the field is complex, and the armature consists not of one coil but of a number of coils set around the circumference of a circle, and these are carried successively through a series of magnetic fields in which the lines of force run alternately in opposite directions. In this case the current in any one coil undergoes one complete alternation during the time which it takes to pass from the centre of one field to the centre of the next field but one. It will, therefore, be evident that the form of the curve which represents the rise and fall of the electromotive force will depend in part upon the shape of the poles of the field magnets and upon the distance between the centres of the successive fields. It might, therefore, easily happen that the curve belonging to a machine of this construction might be quite different from a sinusoid. In the case of the Siemens machine, Prof. Silvanus Thompson states in his book on "Dynamo Electric Machinery" (second edition, p. 332), that it "follows the sine law fairly well." This statement seems also to be supported by the authority of Joubert, but upon the other hand, in the discussion on Dr. Hopkinson's paper on "Alternating Machines," read before the Society of Telegraph-Engineers in 1884, Mr. H. E. Harrison stated that the results of some experiments which he had made proved that "the curve of true sines lies wholly within the curve of the machine."

If, however, we assume that the sine curve is a sufficiently close approximation for the Siemens dynamo, then, in order to adapt the previous formulæ for use with this machine, we have only to take T as representing, not the period of one revolution, but the period of one complete alternation. The expression for θ will then remain the same as before, namely,

$$\theta = 2\pi \frac{t}{T};$$

but its definition will be altered in accordance with the new meaning attached to the symbol T. With these changes all the formulæ already obtained, and (unless the contrary is stated) all that follow, may at once be applied to machines of this class. Having stated this we shall now return, for the sake of simplicity in the theory, to the case of a simple armature rotating in a uniform and simple field.

Before proceeding, however, I should like to take this opportunity to make a small suggestion. Would it not be well to establish the convention that the symbol for a continuous current shall always be C, and that I should be reserved for alternating currents?

Let us now proceed with the subject. It will be useful to have an expression for the current which would be due to the electromotive force of self-induction if that were acting alone. We shall then be able to express the actual current as the sum of the two hypothetical currents due respectively to the impressed and the self-induced electromotive forces.

We have already seen that the E.M.F. of self-induction is given by the equation

$$E_2 = -\frac{d\,L\,I}{d\,t}$$

If we write I″ for the current due to E_2 and divide both sides by R (L being a constant) we have

$$I'' = -\frac{L}{R}\,\frac{d\,I}{d\,t}$$

Substituting for I from (9) this becomes

$$I'' = -\frac{L}{R}\cdot\frac{d}{dt}\cdot\frac{2\pi N}{RT}\cdot\frac{\sin\theta - a\cos\theta}{1+a^2}$$

that is

$$I'' = -\frac{2\pi N}{RT}\cdot\frac{a(\cos\theta + a\sin\theta)}{1+a^2} \quad . \quad . \quad . \quad . \quad (11)$$

Writing a in full, and making a similar transformation to that employed for I, we find

$$I'' = -\frac{4\pi^2 N L}{R^2 T^2}\cdot\frac{\cos(\theta-\phi)}{\sqrt{1+\left(\frac{2\pi L}{RT}\right)^2}} \quad . \quad . \quad . \quad (11a)$$

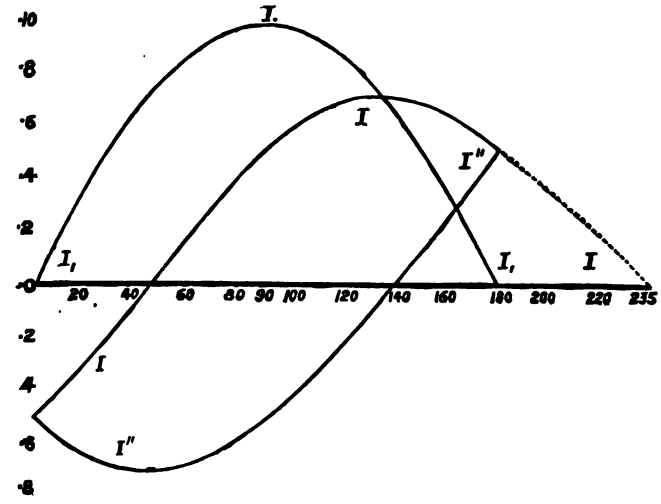

Fig. (1) $\frac{2\pi N}{T} = 1$; R=1; L=N.

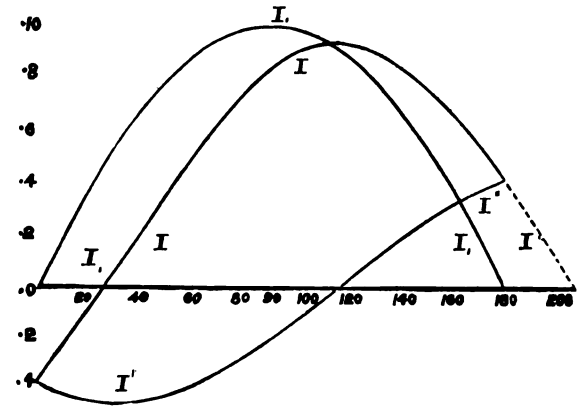

Fig. (2) $\frac{2\pi N}{T} = 1$; R=1; L=½N.

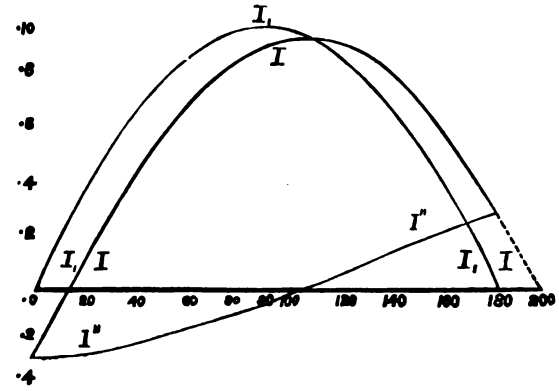

Fig. (3) $\frac{2\pi N}{T} = 1$; R=1; L=¼N.

We will next examine the three equations for the impressed, the self-induced, and the resultant currents by the aid of the curves to which they correspond. The equation for I″ has

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just been given. For convenience of reference, we may repeat from the last paper the equations for I_1 and I:—

$$I_1 = \frac{2\pi N}{RT} \sin\theta$$

$$I = \frac{2\pi N}{T} \frac{\sin(\theta - \phi)}{\sqrt{R^2 + \left(\frac{2\pi L}{T}\right)^2}}$$

In the foregoing figures we have assumed that T has a constant value, and we have taken $\frac{2\pi N}{T}$ to be equal to unity upon the scale of ordinates. If we further make R equal to unity each curve will at the same time represent both electromotive force and current. This condition is assumed in figures (1), (2), and (3). The value of L alone differs in the three cases. In the first figure $\frac{2\pi L}{RT}$ (that is, a) is made equal to unity, and as we have already put $\frac{2\pi N}{T}$ equal to unity, this is equivalent to making L = N. In Fig. 2 we have taken $L = \frac{1}{2}N$, and in Fig. 3 $L = \frac{1}{4}N$.

From these curves the cause of the retardation of the resultant current is very obvious. The impressed E.M.F. and current has zero value when $\theta = 0$, but the resultant E.M.F. and current must become zero at that particular value of θ for which its two constituent terms are numerically equal, but with opposite signs; we have already seen that this condition is fulfilled at the angle whose tangent is equal to $\frac{2\pi L}{RT}$.

We may also notice the following points, each of which are implicitly contained in the formulæ, although they are much more readily observed from the figures.

(1) The curve of the resultant current cuts the axis upon the same ordinate as that upon which the induced current attains maximum values (both + and −).

(2) The resultant cuts the curve of the impressed current at the moment when it attains its maximum value; this is also the moment when the induced current has zero value.

(3) The fact that the impressed and the self-induced currents always "oppose" one another does not imply that they are at all times opposite in sign.

On the contrary, during a portion of each semi-revolution (or semi-alternation) these terms have the same sign. The period during which they are alike in sign is that during which θ has successive values from $\pi - \left(\frac{\pi}{2} + \phi\right)$ up to π. But the two currents still oppose one another during this period in the sense that while one is diminishing the other is increasing, and *vice versâ*.

(4) The statement that "the angle of retardation is constant" does not imply that the numerical values of the impressed and induced currents follow one another at the same intervals throughout the curves. In that case the curves could not cut one another. The meaning of the statement is limited to the consideration of *similar points* upon the two curves, such as the points of maxima and minima for instance. These will be found to follow one another at a constant interval.

In the next paper we will consider the effect of varying the resistance and the period.

ON PYROELECTRIC AND DOUBLY REFRACTING CRYSTALS, DIELECTRIC ACTION AND KERR'S PHENOMENON.

BY MISS J. M. CHAMBERS, B.SC.

We know that certain crystals, called pyroelectric (which are also doubly refracting and exhibit hemihedry), show electro-statical polarity when their temperature is altered. Thus, if they are heated one end becomes as if it were positively electrified, and the other end as if it were negatively electrified. If we pass a flame over the surface, this effect disappears as long as the crystal remains at the same temperature. But as the crystal cools electricity again appears at the same two ends as before, but the signs are now reversed. Sir W. Thomson has supposed these phenomena due to a polarity of the molecules in a certain direction, and that this polarity varies with the temperature. When the crystal is in contact with a conducting body, such as flame, electricity is attracted to the exterior of the body so as to mask the polarity.

Here the molecules appear to act as if they were charged with more electricity at one end than at the other (or, if we prefer, we may say that they have an excess of positive electricity at one end, and of negative at the other), and as if their charged ends were all turned one way. These bodies are crystallised, and crystallisation appears to exert a strong effect on the molecular arrangement. [It is probably the molecular arrangement which causes the ordinary rotation of the plane of polarisation of light in quartz. Of course it is well known that quartz is hemihedral, and that the rotation, whether right or left-handed, depends on the sign of the hemihedry. Quartz is pyroelectric. It is also said to possess a permanent diamagnetic polarity.]

When an electrophorus is rubbed with cat-skin we know that it becomes electrified. An actual positive charge is carried off with the cat skin, and the dielectric plate retains an actual negative charge. At the same time this negative charge will not pass off by merely touching the dielectric, as in the case of a conductor; in fact the only means of discharging the dielectric seems to be by heating it in a flame, and even this often does not do it completely, for, when the dielectric is again cool, a certain amount of charge reappears.

Now, suppose in some dielectrics the same polarity of the molecules exists as in pyroelectric crystals (this may be the case in some dielectrics without necessarily being so in all), but that, since the body is uncrystallised, the molecules are free to place themselves in any direction they please as long as no constraining force acts on them. As soon as the body is placed in a field of statical force the molecules will tend to place themselves so that their poles are joined by the lines of force. The reason that they will not, perhaps, all do this completely is that one molecule acts on another just as in magnetic bodies, and thus the action of the field is more or less interfered with. Thus, we have in the case of the dielectric just the same sort of thing as a magnetisable body, which, however, does not retain its magnetism when the magnetising force is removed, while in the case of the crystal we have a body permanently magnetised. The permanent polarity of the cyrstal is, however, masked by the electricity, which it gradually attracts to itself. In the case of a permanently magnetised body there is no similar manner of masking the magnetism present. This permanent polarisation here appears intimately connected with crystalline form.

Now, as I said before, we charge an electrophorus by stroking it with cat-skin. Taking the above idea of polarised molecules we may suppose the following action to take place. We may suppose that during this stroking some action takes place between the dielectric and cat-skin, owing perhaps to a difference of potential between them, which tends to make the surface molecules of the dielectric place their axis all in the same direction, and their negative ends uppermost, and that the free positive electricity which would neutralise this polarity is carried off by the cat-skin while the negative remains internally, thus, on the whole, giving the body a negative charge as well as a polarity. The reason of the cat-skin carrying off the positive charge may be due to the heat generated by the friction which momentarily changes the state of polarity of the molecules, and the former state of polarity is restored when the temperature again sinks.

We know that a long thin needle of a dielectric will point along the lines of force in a strong field of statical force, just as a needle of a magnetic substance points along the lines of a field of magnetic force.

It is well knewn how uncertain is the sign of the charge of large masses of certain dielectric substances. They may appear to have externally a positive charge, and yet when placed in a metallic insulated vessel a negative charge may be indicated, and *vice versâ*.

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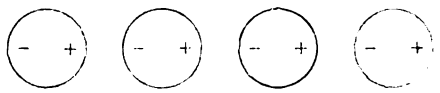
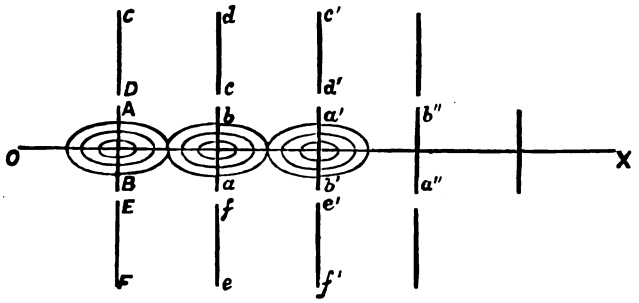
Perhaps in dielectrics with polarised molecules a certain amount of the energy expended in charging a condenser goes to turn the molecules just as a certain amount of energy is required to magnetise a magnet. And perhaps it is the gradual depolarisation of the dielectric that gives the residual charges in condensers. The energy used up in the polarisation is represented by the charge which is masked by it. Thus, suppose when a condenser is first discharged the molecules have all been turned in one direction by the electric force, as the figure shows, then there



will be a layer of positive electricity left on one end, and of negative on the other, to balance this polarisation. But the molecules being no longer subject to so great a constraining force as before will be now more inclined to place themselves in any direction, owing to the force exerted by one molecule on another. The electricity left at the surfaces of the dielectric will, in consequence of this depolarisation, become more or less free, and each removal of it will facilitate the turning of the molecules or the depolarisation of the body as a whole.

Of course it is not necessary that all dielectrics should have these polarised molecules. This polarity may vary in different bodies just as magnetic polarity varies. Dielectrics which give no residual charge may probably have unpolarised molecules.

In my "Simple Manner of Explaining Clerk Maxwell's Theory of Light" (*Phil. Mag.*, Feb., 1886, and *The Electrician*, Feb. 5), there is an action which may take place between the molecules which I have neglected to mention. Take a row of molecules above the first row. There will be a statical condensing



action between A and D and between B and E (on the same principle as in the new system of telegraphing with trains in motion). This condensing action should depend on K, the specific inductive capacity. Now, in my article I have treated the matter as if the whole transverse vibration took place in one molecule, while in point of fact, from the hypotheses on the size of molecules, it probably traverses several, and this condensing action is called into play as well as the one in accordance with Lenz's law. Thus we can see how K will affect the velocity of propagation.

In my articles on the "Rotation of the Plane of Polarisation of Light" (*The Electrician*, May 21st), and on "Hall's Phenomenon" (*The Electrician*, June 4th), I consider the action of magnetic and diamagnetic media on the two circularly polarised rays into which a plane-polarised ray can be resolved. I now propose to consider the action of the medium on the two rays plane-polarised at right angles to one another, into which a plane-polarised ray can be resolved.

Suppose we have an isotropic substance subjected to great pressure in one direction, the molecules will be brought closer together in that direction, and the condensing action will be increased in that direction; hence we can understand why pressure causes double refraction in glass, &c.

Again, in any substance in which there is a permanent polarity, as in pyroelectric crystals, probably this polarity has a fixed direction relatively to the shape of the molecule, and may be either along the longest or the shortest axis of the molecule, hence we may suppose that the molecules are closer together in one direction and farther apart in the other, in the same way as a solution with iron filings becomes clearer in one direction than in the other when acted upon by a magnetic force. It is not, however, necessary that the centres of the molecules should remain at the same distance apart in the two directions, as this supposes; for we may as readily suppose the velocity affected by the *number* of the condensing actions, that is the *number* of molecules traversed. In either case we can see why light should travel faster in one direction than in the other. Probably there is the same molecular arrangement in all doubly refracting crystals, but that when the molecules are not polarised they do not show pyroelectricity. Thus double refraction is accounted for in crystals.

Finally, in Kerr's phenomenon the molecules, when naturally polarised, place themselves along the lines of force with their plus and minus ends joined by those lines. As in the case of pyroelectric crystals, this polarity has probably a definite relation to the shape of the molecules, so that the condensing action is either greater or less along the lines of force than in the perpendicular direction, according as the substance appears to be expanded or contracted along these lines. Hence the double refraction. Even if the molecules are not polarised they would probably place their long axes along lines of force in this case, and there would still be double refraction. This is on the principle that a conductor points with its long axis along the lines of a statical field. Thus the charges which collect at the two ends produce a couple which tends to turn the conductor.

It is well known in the case of Kerr's phenomenon that the effect is far greater than what can be accounted for by the *pressure* exerted by the electric force. Not only is this the case,

but the double refraction takes place in liquids, in which, of course, the *mechanical* pressure must be equal in all directions.

On the other hand, strange to say, from the experiments of Duter, Righi, and others (*Journal de Physique*, *t.* VIII. p. 82, *Comptes Rendus*, *t.* LXXXVIII. p. 1,262), it appears that the actual compression is not so great as would be given by a mechanical pressure of the same amount, and, instead of being inversely as the square of the thickness of the dielectric as theory requires, it is inversely as the first power of the thickness. This also points to the fact that part of the energy is used up in the polarisation, also perhaps to the fact that the molecules are longer in the direction of the polarity than in the other.

THE PHELPS INDUCTION TELEGRAPH.*

The electrical section, acting as a sub-committee of the committee on science and the arts, to which was referred for examination the system of induction telegraphy invented by Mr. Lucius J. Phelps, of New York, presents the following report:—

A sub-committee of five members of the section visited New York September 28th, by invitation of the Phelps Induction Telegraph Company, and inspected the operations on a line worked by this system laid on the Harlem River branch of the New York, New Haven, and Hartford Railroad. The inventor, Mr. L. J. Phelps, and the secretary of the company, Mr. H. D. Hall, accompanied the committee. The branch has a double track from Harlem to New Rochelle, a distance of twelve miles, and the line is laid for this distance on the up-bound track. It consists of a No. 12 copper wire, insulated with okonite, laid in a groove cut in a 3in. by 3in. spruce strip, upon the top of which is tacked a ½in. strip, as shown in Fig. 1.

This wire is brought into the station at Harlem, where it is connected with a battery of 150 cells of a modified Bunsen

* Report of the Committee on Science and the Arts in the *Journal* of the Franklin Institute for July.

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type, and to the ground. It is grounded at New Rochelle, but does not enter the office at that point. A combination car on each of three trains is equipped with the apparatus. An induction coil of ninety turns of No. 14 insulated copper wire passes through a 2in. iron tube, suspended under the car longitudinally between the trucks about seven or eight inches from the line wire. The upper portion of the coil passes through the car, and is hung along the side over the windows. The instruments are set up in the baggage apartment of the car. In a cabinet under the desk is a battery of twelve Bunsen cells.

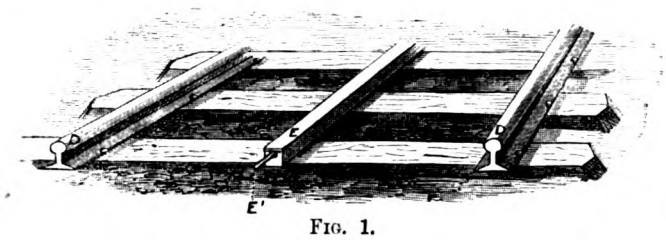

FIG. 1.

As the train left the station at Harlem the committee left messages with the operator at that point which were promptly sent to the parties on the train to whom they were addressed. Messages were also sent by the committee from the train to various parts of the country, which were received at Harlem, and forwarded by other lines. Three members of the committee, who were expert operators, did most of the work on the train. The messages were received on the car either by the Morse sounder or the telephone, in which could be read the Morse signals. The sender's key, however, instead of simply making and breaking the battery circuit, put in action, when depressed, a vibrator, or "buzzer," which sent alternate positive and negative currents to the line, producing a musical tone in the telephone so long as the key was held down. These rapid breaks were repeated in the induction coil circuit in which the telephone was placed, on the well known principle that whenever the circuit of a primary battery is broken or closed a current is set up in a parallel circuit at the instant of making or breaking. Without the buzzer it would be difficult to distinguish the dots and dashes in a telephone; with it, the letters can be read with even greater ease than by the ordinary Morse sounder. When the latter is used, a relay is introduced in the coil circuit with a delicately poised polarised armature which responds only to one pole of the battery, and therefore does not reproduce the rapid breaks heard in the telephone. Its movements, therefore, correspond with movements of the sender's key. It requires a more powerful current to work this relay than is required by the telephone. The battery carried on the car is not sufficient to operate the relay at the Harlem office, and all messages were received at that office by the telephone. This makes it necessary for the operator at that office to be constantly on the watch for business, as there is no means of calling his attention if the telephone is not at his ear. On the contrary, the operator in the car can switch in his Morse apparatus and can hear the call at a considerable distance when the train is moving.

After a stop of a few minutes at New Rochelle, the return trip to Harlem was commenced on the down-track, upon which there was no wire laid. The distance between the line laid on the up-track to the lower portion of the coil when on the down-track was 10ft. 11in., yet messages were received quite as well as when the coil was but eight inches from the line, although the tone in the telephone was much weaker, too weak to have any effect upon the relay of the Morse apparatus. It will be seen that the operator at Harlem could not receive messages sent from the train as readily as before, as the effect of the small battery on the car upon the line must have been quite weak; nevertheless, the messages were correctly received. It may be mentioned here that the upper portion of the coil was on the opposite side of the car from the up-track; had it been on the side nearest that track, it would have been nearly at the same distance from the line as the lower portion of the coil, and there would have been no sound in the telephone, as the currents induced in the opposite sides of the coil, being of equal strength, would have neutralised each other.

The test demonstrated the entire practicability of telegraphing between a terminal station and a moving train when but one line is used. If two lines were to be laid, it is evident that there would be an interference between the two in the induction coil on the car unless some means were devised for neutralising one of them. The system provides for this by so hanging the coils that the two sides will be as nearly equidistant from the circuit to be neutralised as possible. With two coils thus arranged, both circuits could be used simultaneously on the same car. Fig. 2 shows arrangement of coils.

The system, however, does not seem to provide for the neutralisation of the induction from one track line to the other line on the same track, which would be much stronger than the currents from the small battery on the car. For instance, it would be impracticable for the train despatcher to receive a message from a train while a message was being sent to that train or another train on the other line wire.

If several trains were upon the road at the same time, all would be in electric communication with the train despatcher by the same wire, but not with each other, because this would require a double induction, first from the car to the line and then from the line to the second car, and the battery carried on the car is far too weak to produce any results in the other car. If, therefore, the two trains should call the despatcher's office at the same time, the despatcher must say which one is first to use the line, as neither train would know that the other was calling.

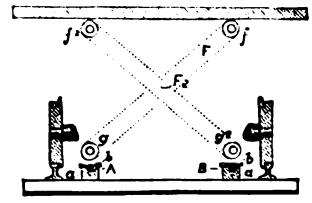

FIG. 2.

Your committee does not consider that its duty requires consideration of the many questions of railroad management which would arise if an opinion were to be expressed about the practical application of the system to existing railroad lines. The essential feature of the invention is the utilisation of induction to maintain communication between a moving train and the despatcher's office. That is successfully accomplished by ingeniously constructed mechanism worthy of high commendation. It is for the inventor and railroad managers to find practical use for the new system.

DEMONSTRATION OF THE ELECTRICAL RESIDUE.—Dr. Fr. Stenger, in Wiedemann's *Annalen*, according to the *Phil. Mag.*, says:—"If two strips of tinfoil are fastened at a suitable distance on a glass tube which has been evacuated as completely as possible, and are connected with the electrodes of an induction coil, continuous electrical currents are formed in the interior, and the gas becomes intensely luminous. If, then, the two tinfoil rings are insulated, the tube becomes luminous at frequent intervals, and often for several minutes together. This doubtless arises from the formation of a residue on the sides of the glass. The experiment was made in a far more striking manner as follows:—In a glass tube, about 2 centim. in the clear, closed at one end, a thin metal foil was introduced so that it covered about half the inner side. A wire soldered to this plate was hermetically sealed in the tube, and was provided on the outside with a small knob. Opposite the metal cylinder a strip of tinfoil was fastened. This small Leyden jar was then rarefied as completely as possible, and hermetically sealed. If this was charged from a small electrical machine for ten or fifteen minutes the residual electricities could be discharged, producing a bright illumination in the tube. This method of rendering visible very small quantities of electricity might possibly be used in repeating in another form the experiments of Roland and Nichols, on the formation of the residue in quartz and calc-spar.

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THE ELECTRICIAN.

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IMPERIAL TELEGRAPHS.

Those whose hopes of Imperial Federation rest on the spontaneous growth of closer relations between her Colonies and the Mother Country, rather than on the artificial stimulus of political activity or personal enthusiasm, will find nothing to quarrel with in the proceedings of the Congress of the Chambers of Commerce of the British Empire, opened at the Indian and Colonial Exhibition last Tuesday week. Never before has such an opportunity been afforded for discussing the commercial interests of this great Empire in a truly Imperial spirit; and the event can hardly fail to be of service to all the countries concerned, though probably none of their representatives were so sanguine as to suppose that any bond more durable than that of mutual self-interest can be fashioned at present for holding the Empire together. Loyalty, patriotism, pride of race, are not the creations nor the creatures of discussion; they may be strengthened by a common danger in time of national peril, they may be fostered by friendly intercourse on occasions of national hospitality, but they cannot be formulated—much less forced—into a legislative mould; and our recent experience of constitution-making, even on a small scale, is not an encouraging precedent. The instinct of commerce, however, may do for us what the passion of nationality might shrink from attempting; and if anything will bring about a Federation of the Empire in the ordinary course of things we should be inclined to back Political Economy rather than political sentiment.

Among the foremost commercial considerations tending in the direction of Colonial and Imperial unity are the expansion and perfection of our Submarine Telegraph system. A short but interesting paper on this subject was read the first day of the Congress by Sir JAMES ANDERSON, and was reported at length in our columns last week. In the discussion which ensued, both at the Congress and in the Press, Sir JAMES ANDERSON appears to have created some alarm lest the Reforms suggested by him should involve an increased tariff—which in point of fact he greatly deprecated—and the abolition of code messages, which, however, he only threatened for those who were abusing the system. As regards increased rates, it is obviously not in the interest of the Cable Companies to diminish traffic; and, within certain limits, it is equally not their interest to forbid Code. But the Companies are quite justified in saying, if a privilege is abused to their serious inconvenience and pecuniary loss, that either the rates must be raised or the abuse removed. To neither of these remedies, however, did the paper recommend the Companies to resort. One of the means suggested for obtaining cheaper cabling was an inter-colonial subsidy or guarantee; and it would assuredly follow that no Government, whether English or Indian or Colonial, would allow itself to be fleeced by the unscrupulous employment of codes. The International Telegraph Conference legislates on this subject. If its members were owners as well as legislators they would enforce what they enact; but this is what in practice the Companies competing with each other are unable to do.

The unnaturally low rates which prevail on the Atlantic Cables put them out of discussion just at present, and Sir JAMES ANDERSON occupied himself chiefly with the cable system of the Eastern Hemisphere. To India and Australia the rates are exceedingly high, though, considering the distance, they are really much cheaper than those which are charged on inland telegraphs, which cost much less to erect. Small abatements make little difference in the traffic; and to grant a sensible reduction on a tariff of, say, 8s. or 10s. per word would inflict a heavy penalty on the proprietors of cables, who earn only a moderate dividend at the present rates. Experience has shown that the resulting increase of traffic will in a few years' time bring the revenue up to its old figure; but it has proved also that where this process has been compulsory by reason of competition the interval represents a serious loss, which is never made up by the business afterwards shared among the competitors. Cable owners are business men and not philanthropists, as Sir JAMES ANDERSON justly remarks; and the telegraphing public have no right to ask them to make a heavy sacrifice merely for the public benefit. He therefore submitted to the Congress two or three suggestions, by the adoption of which the public would be gainers and the Companies not losers. One method is for the State, or a number of States, to guarantee 4 per cent. dividend on the existing cables; another, which has actually been adopted by Germany in the case of one company, is to guarantee a certain amount per annum, but under conditions which will result, at the end of a given period, in the cable becoming the property of the German Government. A third plan is the one which is now being discussed with the Australian Colonies, whereby the average net earnings of the Companies during the past three years are assured them, the Colonies then reducing the tariff as low as they please.

These and other suggestions which have been under discussion all provide that the Companies shall not be gainers, the

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Government aid coming only in the shape of a temporary guarantee, not as a permanent subsidy. They are not put forward in the names of the English Companies, or in their interests, but as friendly suggestions to our Colonial brethren, who, if they want a cheaper telegraphic tariff to Europe and India, are invited to accept some of the risk. There is a precedent for it in the mother country, where the State acquired the whole of the telegraphs in order to give the public a cheap tariff, which the private Companies could not afford to give. Events have shown, on the one hand, that the English Companies were right in not reducing their rates, and, on the other, that the State has not suffered—or did not until it took the new departure of last year—a permanent loss by assuming this responsibility. As to the alternative of a Pacific cable for the Australian service, we stated our views very emphatically as soon as the idea was broached. Sir JAMES ANDERSON has now argued the proposition so thoroughly that one may hope it is dismissed for ever. Cables follow trade, and so do the enemies' cruisers. Strategic cables can be laid when and where they are wanted. To lay long, deep sea, unremunerative cables is to invite certain loss in time of peace and immediate destruction in time of war.

Indirectly, no doubt, the Cable Companies might benefit by State responsibility and control of their tariffs which Sir JAMES ANDERSON'S suggestions would involve. The respective Governments would all be anxious to protect the property in which each of them was interested. At least this is theoretically probable; and of course the tendency would be to make for peace, just as trade and commerce make for it. Whether cable property would be respected in actual warfare is another matter. Probably it would if England were not in the fight. But as England owns perhaps eight-tenths of all the world's submarine cables, the probability of their being unmolested if she were at war with another maritime nation is very remote indeed. Continental nations are not likely, we fear, to sign away their natural advantages as we were so quixotic as to do by the Declaration of Paris. International understandings, however, have a value independently of their ostensible aim, and we should be glad to see any of Sir JAMES ANDERSON'S suggestions carried out among the leading maritime nations of Europe. In practice we can never get the Cables neutralised; but the next best thing is to lay them in such wise as to be easily protected if we have to fight for them, and quickly repaired if they are broken.

CORRESPONDENCE.

MAGNETIC RESEARCHES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The last number of your journal, as well as the *Philosophical Magazine* for July, contains some interesting researches upon magnetism by Prof. G. Wiedemann, and I quite agree that they are fully explained by the movements of magnetic molecules, as first formulated in the theory of magnetism of De La Rive, and since extended by the innumerable researches of many independent observers, including myself.

The theory which I have advocated is based, not only upon my own experiments, which seemed to me to demonstrate clearly its truth, but upon the important researches of many others, including Prof. Wiedemann, and for which I have given them full credit.

I have proposed that this theory should be called the "Mechanical Theory of Magnetism," as granting that each molecule of iron or other magnetic metal is an independent and unalterable magnet. We can then reproduce all the known phenomena of magnetism by a mechanical change or arrangement of these magnetic molecules.

Prof. Wiedemann agrees with these views, but he now claims to be the first to have formulated this theory, dating his claim from papers published since 1857, although I have shown that it was first advanced by De La Rive in 1853.

The following is a quotation from my first paper upon the "Theory of Magnetism," Royal Society, April, 1883, relating to the theory which I advocated, and carefully pointing out its resemblance with that of De La Rive:—

"This theory has long been foreseen, and predicted in almost complete perfection as regards the rotation of the molecules, by many authors, the earliest of whose notices, and the most clearly defined as being very near the results obtained by myself, will be found in the remarkable work by De La Rive,* 1853, who in Chapter III., page 317, under the title of 'Influence of Molecular Actions upon Magnetism produced by Dynamic Electricity,' says: 'We have seen that heat, tension, and mechanical actions generally facilitate magnetisation. M. Matteucci has found that torsion and percussion, and mechanical actions, not only facilitate the magnetisation produced upon soft iron by a helix that is traversed by a powerful current, but they also contribute, when the current has ceased to pass, to the destroying the magnetism in a very rapid manner; the same philosopher has likewise observed that torsion, when it does not pass beyond certain limits, augments the magnetisation produced upon steel needles by discharges of the Leyden jar.

"'M. Marianini, who has made numerous and interesting researches upon magnetisation, arrived at curious results upon the aptitude that iron bars may acquire of becoming more easily magnetised in one direction than in another.'

"M. De La Rive sums up a series of interesting experiments in these remarkable words: 'The whole of the magneto-molecular phenomena that we have been studying lead us to believe that the magnetisation of a body is due to a particular arrangement of its molecules, originally endowed with magnetic virtue, but which in the natural state are so arranged that the magnetism of the body that they constitute is not apparent. Magnetism would therefore consist in disturbing this state of equilibrium, or in giving to the particles an arrangement that makes manifest the property with which they are endowed, and not in developing it in them. The coercitive force would be the resistance of the molecules to change their relative positions.'

"'There remains an important question to be resolved:—

"'Are mechanical or other actions, disturbers as they are of the electrical state, able of themselves to give rise to magnetism?'

"Du Moncel, in his remarkable work on magnetism, 1857, sustained and developed the views of De La Rive, and later, Wiedemann in Poggendorff's *Annalen*, 1857-1859, as well as in his remarkable 'Lehre von Galvanismus,' 1861, sustained a similar theory. Wiedemann has lately given a *resumé* of his researches in the *Lumière Electrique*, Paris, January 28, 1882, where he says—

"'Nous admettons que les metaux magnétiques sont composés de molécules qui sont une polarité magnétique; nous ne voulons rien préciser quant à la cause même de cette polarité, qu'elle provienne de la séparation des fluids magnétiques, des vibrations d'un milieu entourant les molécules ou mieux encore de l'existance de courant élémentaires.

"'Un corps ainsi constitué n'aura pas, en général, de magnétisme libre, parceque les axes magnétiques des molécules seront dirigés dans tous les sens et maintenus dans leurs positions respectives par les forces moléculaires. Mais une force magnétique extérieure, telle qu'une hélic où passe un courant leur donnera une direction générale.

"'En poursuivant cette hypothèse, M. Weber a réussi à expliquer théoriquement l'accroisement de la magnétisme d'une barre soumisse à l'influence d'une hélice aimantée jusqu'à un maximum.

"'Nous supposons, en outra, que les molécules dans leur mouvement éprouvement une certain résistance qui les empêche de suivre complètement l'influence des forces qui agissent sur elles.'

"In my preliminary note I gave the formulated results of a lengthened series of researches upon magnetism by the aid of the induction balance. As these agree in all important points with the theory of De la Rive, 1853, I do not wish it to be considered as a new theory or conception of molecular rotation, but as a theory based entirely upon researches into all the conditions of magnetism, and one which clearly defines the conditions of polarity and neutrality."

It is quite possible that the main points of this theory were published even before 1853, but in order to do justice I not only searched diligently through papers upon this subject, but wrote to my friend the late Comte Du Moncel (who had a remarkable knowledge of these earlier researches), asking him to point out the first to formulate this theory. His reply was, "undoubtedly, De La Rive."

It remains now for Prof. Wiedemann to show wherein his views differ from those of De La Rive, or cite some earlier date than 1857, for I cannot suppose he was not cognisant of the remarkable treatise of De La Rive published in 1853.—

Yours, &c.,
D. E. HUGHES.

London, W., July 13th.

* "A Treatise on Electricity, in Theory and Practice." By Aug. De La Rive, London, 1853.

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NERVOUS FORCE AND ELECTRICITY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Your correspondent, Mr. Arthur Willey, ought not to conclude that, because nobody has referred to his letter on this subject, therefore nobody has felt any interest in it. There is a kind of self-induction that checks an immediate response to letters public or private. However, it would perhaps be interesting if Mr. Willey would repeat his experiments in such a way as to eliminate the chances of chemical influence in his results about the right and left hand, as by holding platinum instead of copper. And was the deflection obtained a large one or a small one? We were told that the spot went *off the scale;* what would it indicate, according to the construction of the instrument?—Yours, &c.,

37, Burlington-road. E. ALDRED WILLIAMS.

INFORMATION WANTED.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have lately come into possession of a cylindrical electrical machine ("made and sold by Edward Nairne, Optician to Her Majesty, 20, Cornhill, opposite the Royal Exchange, London"), and I should be very much obliged if you or any correspondent will kindly let me know at what date (approximate) the above maker flourished, and in what repute his instruments were held. The machine I have is a splendidly made one. It is described as "Nairne's patent medical electrical machine (for ready money only). As many persons wish to try the effects of electricity, Mr. Nairne has contrived this machine, whereby any person, *without the assistance of another*, may try its effects in all the various methods practised by the most eminent medical electricians."

If you or your readers could furnish me with the required information I should feel much obliged.—Yours, &c.,

30, Edwyn-street, Leicester, July, 1886. T. H.

THE INCANDESCENT LAMP DISPUTE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: We enclose copy of correspondence with the Edison and Swan United Electric Light Company with regard to a most extraordinary means which they are taking to find out who are using other than their lamps. We think that this deserves exposure, as their position is sufficiently strong without resort to this kind of fishing for culprits.—Yours, &c.,

Glasgow, 10th July, 1886. MUIR AND MAVOR.

Copy of correspondence with the Edison and Swan United Electric Light Company.

We have had sent to us, by Isaac Holden, Esq., M.P., in whose residence we fitted a number of your lamps, a letter from you under date 1st July, 1886, as follows:—

"We find that you are using electric incandescent lamps which are made in infringement of this company's patents, which have been recently upheld by the decree of the High Court of Justice, under proceedings instituted by the company against other infringers.

"I have to request that you will at once discontinue the use of these lamps, and upon your notifying me of your willingness to do this, I will make arrangements for sending for the lamps at such early date as may be convenient to you. If I hear from you not later than Thursday next, 8th inst., with the undertaking above referred to, the company will abstain from taking proceedings against you, either for an injunction or for damages—a course which the directors have authorised me to take—in the belief that you were not aware that by the use of the lamps in question you were infringing the company's rights."

We think this a most unwarrantable and vexatious proceeding on your part, calculated to have a very prejudicial effect on your interests and ours.

We are using your lamps exclusively, and think that you owe us an apology for this procedure.—Yours, &c.,

MUIR AND MAVOR.

Glasgow, 9th July, 1886.

ANOTHER ATLANTIC CABLE SUGGESTED.

Although at the present time there are in the Atlantic more than sufficient cables to do all the work required of them, as well as the probable increase of traffic for many years to come, a suggestion is being pushed by some French promoters to establish yet another system of submarine cables connecting Brazil with the United States and the various French colonies. For this purpose an attempt is being made to obtain a subsidy from the French Government. The question was discussed in the Chamber of Deputies, a full report of which we have had an opportunity of perusing in the *Journal Officiel* of the 12th inst. M. Bizarelli, on behalf of the Government, proposed a motion claiming urgency for the question, which immediately brought another deputy to his feet, in the person of M. Lucien de la Ferrière, who, in an exhaustive speech, opposed the motion on the grounds of an absence of urgency. He pointed out that what the Chamber was in reality asked to sanction was a subsidy of a million francs per annum for the next twenty-five years. What, of course, the promoters of the scheme urge on the Government is that the establishment of the new telegraphic route would be a more rapid and safer medium of communication between France, the Antilles, and French Guiana, and thus afford greater scope for the development of the French colonial trade. M. de la Ferrière had nothing to say against the motive which animated the Government in regard to the subject, which might, no doubt, be very praiseworthy, more especially in view of what they had now to disburse to the companies of other nations. Nor was he inclined to cavil at the principle of a proposal which might give an impetus to the manufacturing industries of France. What he protested against was the eagerness to grant urgency for the question, which might lead to precipitate action, the effects of which they might ultimately have very great reason to regret. The agreement which the Chamber was asked to ratify was with a company which had not even reached the embryo stage of its existence, and, he added, amidst the approving cheers of the Right, whose baptism had preceded its birth. He then proceeded to call the attention of the Chamber to two of the articles of the *projet de loi*, namely, the 1st and 12th. The first of these refers to the concession which it is said the Count d'Oksza has obtained from the Dominican Republic, by virtue of which the company would have the exclusive right to land cables upon its littoral, and connect them with the land lines already established. Before committing the country to such an undertaking M. de la Ferrière wanted to know a little more of the company promoting it; what was the guarantee for its completion which that organisation was prepared to offer; and what was the responsibility which it was proposed to take in regard to an enterprise from which, for all that he could see, it might reap the sole and exclusive advantage; what was to be the legal character of the prospective body; and under what judicial form was it to carry on its work; and what was the extent of its capital? These, and similar pointed questions, M. de la Ferrière desired to have satisfactorily answered before adopting the motion. He went even a little further, and maintained that according to the 12th article of the agreement the capital to be employed would practically be guaranteed by the State—nothing more nor less. Amid a good deal of interruption M. de la Ferrière proceeded to read the article in question to prove his contention. He was succeeded by M. Granet, Minister of Posts and Telegraphs, who urged as the principal reasons for supporting the motion the present unsatisfactory state of communication between France and her colonies. After a few further remarks from M. de la Ferrière, the Chamber came to the conclusion that urgency had not been established, there being 252 "ayes" and 258 "noes." Under these circumstances the first discussion of the question has been adjourned.

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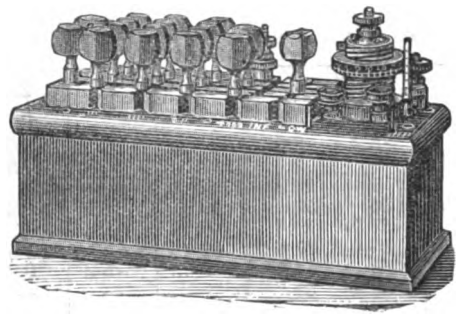
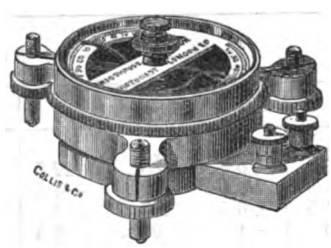
PORTABLE TESTING APPARATUS.

We have often remarked that it is necessary for the permanent success of electric lighting that the work should be tested as closely as telegraphic work is tested, and it is among the signs of the times that apparatus is being specially designed and constructed for this class of work. We herewith illustrate a portable combination bridge, manufactured by Messrs. Woodhouse and Rawson, which has been designed for them by Messrs. H. Davies and E. J. Moynihan. The great danger to be feared when careful testing is not carried out, and which is not yet properly recognised by electrical engineers erecting installations now considered perfectly satisfactory, is that a small fault unnoticed from a want of proper testing develops rapidly to an alarming extent, and that in some cases it soon causes a breakdown. To carry out a series of thorough tests



Woodhouse and Rawson's Portable Testing Apparatus.

it is necessary to have instruments for the measurement of very low resistances, such as the armature of a dynamo and the conductivity of cables and leads, as well as instruments for the measurement of high insulation resistances; and the expense and difficulty of carrying about the amount of delicate apparatus that has hitherto been necessary has no doubt been one of the causes why this most important matter of testing has been neglected. Messrs. Woodhouse and Rawson's combination bridge consists of two distinct bridges in one box, arranged so that the same connections are used with both, the only alteration in shifting from one bridge to the other being the shifting of the contact keys. The first bridge, which is separated from the second by the infinity plug hole, is a Wheatstone plug bridge capable of measuring resistances from 1 ohm to 10 megohms. This has coils of 100 ohms and 10 ohms in one



Woodhouse and Rawson's Portable Testing Apparatus.

ratio arm and 10 ohms and 10,000 ohms in the other, together with coils giving a total variable resistance of 10,000 ohms in the adjustable arm. The second bridge by which resistances may be measured from ·001 to 100 ohms without using a greater ratio than ten to one in either direction is a modification of a slide wire bridge in which the ratio wire is coiled in one groove and the battery lead in the other groove of a double threaded screw cut on an ivory cylinder. Contact is made between the two wires by a double brass spring attached to an ebonite ring, which screws up and down on the ivory cylinder, the ring being graduated from 0 to 100 on each half of its circumference, the number of half-turns being shown by a vertical graduated scale.

The whole length of the slide wire is thus divided into 1,000 parts. The unknown resistance is measured by adjusting the point of contact on the slide wire, which forms the ratio arms of the bridge, and so balancing the unknown against the most suitable of four coils, which respectively have resistances of ·01, ·1, 1, and 10 ohms. The infinity plug hole and the plug holes of these four coils are larger than those of the other part of the bridge, and have but one plug between them, the two bridges being separated by the infinity plug holes.

When the bridge is used for high resistances, the contact keys are turned to "high," and the infinity plug is put in. When it is used for low resistances, the contact keys are turned to "low," and one of the four above-mentioned coils plugged, leaving the infinity hole unplugged.

The use of the slide wire is advantageous for low resistances, and, combined with the other bridge, gives everything required for contractors' testing, and work of a similar character.

The bridge is usually fitted into a strong box, convenient for carrying it, which also contains a pair of large split terminals for connection to heavy cable, a primary or secondary battery, and a very delicate astatic galvanometer, with suspended needles, which is particularly neat and compact, and is provided with levelling screws.

It is sometimes preferred to fit the battery in a separate leather case, with straps for carrying, to prevent possibility of fumes injuring the bridge. The outside dimensions of the case carrying the bridge, spare terminals, galvanometer, and leads are only 13½in. by 5½in. by 7½in., the dimensions of the bridge are 9½in. by 4¼in., and it is undoubtedly the smallest made with so large a range.

MAGNETIC RESEARCHES.*

BY PROF. G. WIEDEMANN.

(*Continued from page 182*)

If the changes of magnetic moment which take place upon torsion enable a conclusion to be drawn as to the rotation of the molecules, it appeared of interest to investigate the processes connected with the changes still further; and first to examine a wire subjected to repeated twisting and untwisting within certain limits.

These experiments were made with the same apparatus, and by the same methods as previously described:—Wires in some cases (temporarily or permanently) logitudinally magnetised by currents led round them, in other cases (temporarily or permanently) transversely-circularly magnetised by currents led through them, were twisted and untwisted through a certain number of degrees, and their moments determined from the deflection of the suspended steel mirror. The deviations produced by the magnetising current were compensated as before. By repeatedly raising and lowering the compensating ring, its constancy during the experiments on temporary magnetism could be controlled.

In the following tables, in order to economise space, the data are given only for the 1st, 2nd, 3rd, and nth torsion and detorsion after twisting the wire to and fro so many times that upon repetition of the experiments the same results were obtained. t denotes the angle of torsion, m_t the temporary, and m_p the permanent magnetic moment.

1. *Soft-iron wire* 2 millim. thick, *temporarily magnetised longitudinally* by a current led round it.

A.

m_t					m_t				
t.	1.	2.	3.	n.	t.	1.	2.	3.	n.
0°					180°				
0...	362·5	354·5	354·1	357·7	180...	353	357·2	358	362·5
30...	367	364	364	366·3	150...	361	369 5	370·5	374
60...	358·5	376	376	378·6	120...	376	379·5	380	384
90...	346	381	383	384·8	90...	375	378	378	381
120...	343	374	375	378·8	60...	367·5	370	370·5	372
150...	343	363·2	364	369·1	30...	360·5	361	360 5	363·6
180...	343	355	355	360	0...	354·5	354·5	355	358
210...	343	348·5	348·2	353		—	—	—	—

* From the *Phil. Mag.* for July.

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B. A similar iron wire magnetised by a very weak current.

t.	1.	n.	t.	1.	n.
0°	116	161·8	180°	148	166·5
30	155	169	150	162·5	178
60	147	184·4	120	189·5	201
90	140·3	197	90	180·5	191
120	140·7	189	60	170	177
150	140·2	174	30	163·2	167·5
180	140·5	166	0	159	162·3
210	140·6	—	—	—	—

C. A similar iron wire magnetised by a very strong current.

t.	1.	n.	t.	1.	n.
0°	385·5	382·5	180°	380·5	381·4
30	387·5	386	150	384·4	385
60	384·7	388·5	120	385·8	387·5
90	381	388	90	386	387·8
120	378·5	386	60	385	385·4
150	377	383	30	884	384
180	376·7	380·4	0	383	382·4
210	376·7	378	—	—	—

D. An iron wire of 3 millim. diameter, magnetised in the same way.

t	0°	30°	58°	60°	90°	120°	150°	180°	210°
n	272	293	307	308	311	298	285	276	267
t	180°	150°	133°	120°	90°	60°	30°	0°	
0	276	292	299	303	302·5	296·1	289	282	

The degrees 58 and 133 correspond to the positions of mechanical equilibrium, after removing the torsional forces, with increasing and decreasing torsion respectively.

2. *Soft iron wire* 2 millim. thick, *permanently magnetised longitudinally* by a current led round it.

	m_p.				m_p.		
t.	1.	2.	*n.*	*t.*	1.	2.	*n.*
0° ...	298	68·2	42	180° ...	147	82·6	48
30° ...	213	70	42·6	150° ...	145	84	48·1
60° ...	172	73	43·1	120° ...	125·6	88·5	45
90° ...	153·6	89·2	44·4	90° ...	94	70	47
120° ...	152·2	93	51·3	60° ...	78	62·5	47
150° ...	147·7	88	50·3	30° ...	72	58	42·5
180° ...	145·8	84	48·5	0° ...	68·2	55·6	42
210° ...	145	81·3	48·2	—	—	—	—

3. *Soft nickel wire* 2 millim. thick, *temporarily magnetised longitudinally* by a current led round it.

	m_t.				m_t.		
t.	1.	2.	*n.*	*t.*	1.	2.	*n.*
0° ...	63·4	88·4	89·4	180° ...	79·6	80·4	83·2
30° ...	80·6	80·4	83·2	150° ...	74·4	75·4	77·2
60° ...	86·2	76·6	77·4	120° ...	79·9	81·2	82·2
90° ...	87·4	83·6	83·0	90° ...	83·6	84·4	86·2
120° ...	87·4	87·4	87·2	60° ...	86·4	87·0	88·4
150° ...	87·6	88·4	89·4	30° ...	87·4	88·4	89·2
180° ...	87·7	88·7	89·7	0° ...	88·4	88·6	89·3
210° ...	87·9	88·6	89·7	—	—	—	—

4. *Soft nickel wire* 2 millim. thick, *permanently magnetised longitudinally* by a current passing round it.

	m_p.				m_p.		
t.	1.	2	*n.*	*t.*	1.	2.	*n.*
0° ...	41	−16	13	180° ...	54	38·5	−17
30° ...	42	−12·8	11·6	150° ...	38	27·5	−13
60° ...	14	− 3·3	7·3	120° ...	18·2	13	− 5·6
90° ...	60	+11·2	− 3	90° ...	4	0	+ 2·8
120° ...	62	24·2	−11	60° ...	− 5·3	− 9	+ 8
150° ...	63	34·4	−14·8	30° ...	−12	−15	+11·2
180° ...	63	40·7	−18	0° ...	−16	−19	+13
210° ...	63	43·4	−18·2	—	—	—	—

5. *Soft iron wire*, 2 millim. thick, *temporarily magnetised transversely* by a current passed through it.

	m_t.				m_t.		
t.	1.	2.	*n.*	*t.*	1.	2.	*n.*
0° ...	0	−121	−118·8	180° ...	90	100	106·2
30° ...	48	−121	−118·4	150° ...	68	81	86·3
60° ...	83	− 88	− 92	120° ...	− 20·2	− 2·2	+ 2·
90° ...	89·6	+ 36	+ 24	90° ...	− 92	− 87	− 84·5
120° ...	90·8	88·6	90·6	60° ...	−114	−113	−112
150° ...	90·5	100·3	106	30° ...	−119·8	−119·4	−118·2
180° ...	90·5	101	107·5	0° ...	−121	−120	−118
210° ...	90·5	99·5	105·2	—	—	—	—

6. *Soft iron wire* 2 millim. thick, *permanently magnetised transversely.*

	m_p.				m_p.		
t.	1.	2.	*n.*	*t.*	1.	2.	*n.*
0° ...	1	− 5·2	8·5	180° ...	94	52·6	30·8
30° ...	100·5	− 5	9	150° ...	88·2	49·5	28·8
60° ...	101	0	10·2	120° ...	40·3	29	20
90° ...	95·5	34	18	90° ...	7·2	11·2	14·6
120° ...	95	52·3	29·8	60° ...	− 1·5	4	11
150° ...	94·1	54·5	31·8	30° ...	− 4·6	1·5	9·5
180° ...	93·8	53	31·5	0° ...	− 5·2	0	8·2
210° ...	93	52·5	31	—	—	—	—

7. *Soft nickel wire* 2 millim. thick, *temporarily magnetised transversely.*

	m_t.				m_t.		
t.	1.	2.	*n.*	*t.*	1.	2.	*n.*
0° ...	0	+86·3	+86·1	180° ...	−69·8	− 72	− 75
30° ...	− 76	+70	+73·5	150° ...	− 6·5	− 9	− 19
60° ...	− 84·2	− 29·8	− 6	120° ...	+50	+52	+54
90° ...	− 85·2	− 76·5	− 68	90° ...	+72	+73	+75·6
120° ...	− 85	− 85·2	− 84	60° ...	+80·8	+81·6	+83
150° ...	− 85	− 87	− 87·8	30° ...	+84·6	+85	+86
180° ...	− 85	− 87	− 88·8	0° ...	+86·3	+86·2	+86
210° ...	− 84·6	− 82·2	− 87·8	—	—	—	—

8. *Soft nickel wire* 2 millim. thick, *permanently magnetised transversely.*

	m_p.				m_p.		
t.	1.	2.	*n.*	*t.*	1.	2.	*n.*
0° ...	+ 0	+6	+0·6	180° ...	−17·5	+1	+3
30° ...	− 20	+5·5	+0·6	150° ...	− 4·5	+3	+3
60° ...	− 24	+1·5	+0·6	120° ...	+ 3	+4	+2·5
90° ...	− 22·8	0	+1	90° ...	+ 4·5	+3·2	+1·5
120° ...	− 22·5	0	+3	60° ...	+ 5·2	+3	+1
150° ...	− 22·5	0	+3·2	30° ...	+ 6	+3·2	+1
180° ...	− 22	0	+3·5	0° ...	+ 6	+3·2	+0·6
210° ...	− 22	0	+3·2	—	—	—	—

The magnetism of the nickel wire had diminished so much after repeated torsion that measurements with it could not be made use of.

The results of these observations for the last torsion and detorsion, after attaining a permanent condition, are represented in Figs. 2 to 9 by curves whose abscissa represent torsions and ordinates the corresponding magnetic moments. The curves marked I., II., III. represent the results obtained with the first, second, and third torsion and detorsion of the soft-iron bar.

The curves show that after the wires have been accommodated by repeated deformation, the curves representing the magnetism are nearly symmetrical for rising and falling torsion,

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beginning from the minimal and maximal torsions of 0° and 210°. With the temporarily longitudinally magnetic iron wires—the moments are nearly equal for the later torsions—they rise similarly in consequence of torsion and detorsion, and then fall again to the limiting-point. The curves, however, rise more rapidly than they fall, so that the maximum of the temporary movements is obtained before the half-torsion or detorsion.

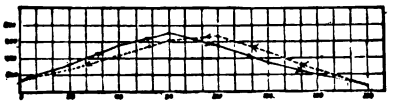

FIG. 2.—Soft iron temporarily magnetised longitudinally.

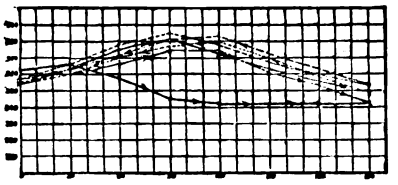

FIG. 3.—Iron wire repeatedly longitudinally magnetised temporarily.

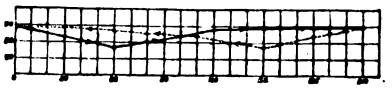

FIG. 4.—Nickel temporarily magnetised longitudinally.

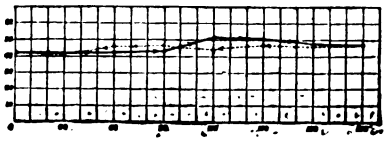

FIG. 5.—Soft iron permanently magnetised longitudinally.

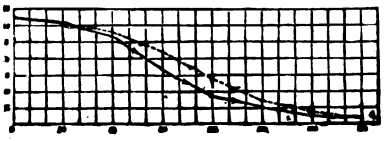

FIG. 6.—Nickel permanently magnetised longitudinally.

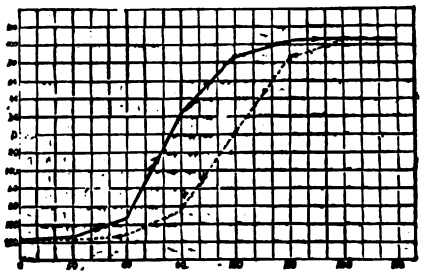

FIG. 7.—Iron temporarily magnetised transversely.

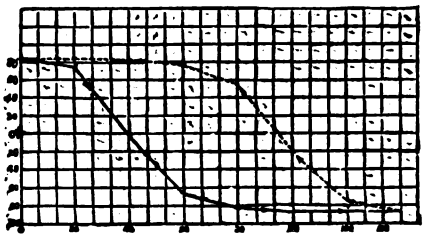

FIG. 8.—Nickel temporarily magnetised transversely.

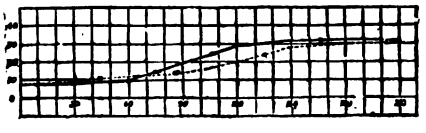

FIG. 9.—Iron permanently magnetised transversely.

With the iron wires permanently magnetised longitudinally and temporarily magnetised traversely, the behaviour is similar, only the moments at the two limiting points of 0° and 210° are different. Starting, however, from these points, the curves run similarly. The moments again change more rapidly at the beginning of torsion or detorsion than at the end. With nickel the moments change in the opposite direction; but in other respects according to the same rules as with iron.

We may hence conclude that, within certain limits, the molecules, in consequence of repeated twisting to and fro, become movable; so that they perform nearly equal motions for equal torsions from the two limiting values. With temporary longitudinal magnetisation the tendency of the magnetising force is to place the molecules with their magnetic axes longitudinal, in consequence of which a final condition is attained in which they deviate at the limiting points equally from their most nearly longitudinal position. *A priori*, we should expect that they would be most nearly longitudinal in the mean position, *i.e.*, at half torsion and detorsion; and there the wire would show its maximum of longitudinal magnetism. The deviation from this result shows that at the commencement of torsion or detorsion the molecules are more quickly influenced by the acting forces.

(To be continued.)

ELECTRICAL THEORIES.

BY PROF. J. J. THOMSON, M.A., F.R.S.

(Continued from page 181.)

Let us now go on to consider the force acting on the medium conveying the current.

If we consider a continuous distribution of currents, the kinetic energy

$$= \tfrac{1}{2}\iiint (Fu + Gv + Hw)\, dx\, dy\, dz.$$

If we derive the force parallel to x by the variation of the energy in the usual way we find, just as in Helmholtz's paper*, that the force parallel to x

$$= \left\{ v\left(\frac{dG}{dx} - \frac{dU}{dy}\right) + w\left(\frac{dH}{dx} - \frac{dU}{dz}\right) - F\left(\frac{du}{dx} + \frac{dv}{dy} + \frac{dw}{dz}\right) \right\}$$

or with our notation

$$= v\left\{\frac{dG}{dx} - \frac{dU}{dy}\right\} + w\left\{\frac{dH}{dx} - \frac{dU}{dz}\right\} - FP,$$

and that on any surface where there is a discontinuity in the values of u, v, w there is a force equal per unit of area to

$$F\{l(u_1 - u_2) + m(v_1 - v_2) + n(w_1 - w_2)\}$$

or $F\Sigma$.

In the same paper it is shown that it follows from the principle of the conservation of energy that the force exerted by a distribution of currents equals the force given by Ampère's expression along with a force at the point $\xi\eta\zeta$ whose component parallel to the axis of x equals

$$\iiint \left(\frac{du}{dx} + \frac{dv}{dy} + \frac{dw}{dz}\right) \frac{x-\xi}{r^4} \Big(u'(x-\xi) + v'(y-\eta) + w'(z-\zeta)\Big)$$
$$dx\, dy\, dz + \iint \left\{ l(u_1 - u_2) + m(v_1 - v_2) + n(w_1 - w_2) \right\} \frac{x-\xi}{r^2}$$
$$\Big(u'(x-\xi) + v'(y-\eta) + w'(z-\zeta)\Big) dS;$$

or with our notation

$$\iiint P \frac{x-\xi}{r^4} \Big(u'(x-\xi) + v'(y-\eta) + w'(z-\zeta)\Big) dx\, dy\, dz$$
$$+ \iint \Sigma \frac{x-\xi}{r^4} \Big(u'(x-\xi) + v'(y-\eta) + w'(z-\zeta)\Big) dS,$$

where u', v', w' are the components of the current at the point $\xi\eta\zeta$; so that in addition to Ampère's forces we have additional forces wherever P and Σ have finite values. From the above

* *Die elektrodynamischen Kräfte in bewegten Leitern*, Crelle, LXXVIII p. 298, 1874, or *Gesammelte Werke*, Vol. I., p. 753.

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expressions we see that any element where P has a finite value exerts a repulsive force equal per unit of volume to

$$\frac{P}{r} i \cos\theta,$$

tending from the element; where r is the distance of the element from the point at which the force is reckoned, i the intensity of the current at this point, and θ the angle between the direction of the current and r. Any element of surface where Σ has a finite value exerts a repulsive force equal per unit of surface to

$$\frac{\Sigma}{r} i \cos\theta,$$

where the notation is the same as before. Of course none of these forces exist in Maxwell's theory. They could be most easily detected in cases where the part of the forces given by Ampère's theory vanishes as it would for the case of an endless solenoid. In this case, though the Ampèrian forces vanish, the forces due to the discontinuity in the current do not, so that if the endless solenoid were to move under the action of external currents it would denote the existence of discontinuity in the current. An experiment of this kind has been made by Schiller; we shall discuss the results of it later.

To sum up, the differences between the most general theory which takes into account the action of the dielectric, and Maxwell's, are—

1. The existence of a normal wave in the general theory, but not in Maxwell's.
2. The difference in the velocity of propagation of the transverse wave.
3. The difference in the relation between electric currents and magnetic force.
4. The forces which arise from discontinuity in the currents.

The Experimental Evidence as to the Truth of the Various Theories.

The theories we have considered may be divided into two great classes, according as they do or do not take into account the action of the dielectric surrounding the various conductors in the field. The first thing, therefore, that we have to do is to see whether experiment throws any light on this point.

When a dielectric is an electric field it experiences a change in its structure; this is rendered evident by the alterations in its volume and elasticity observed by Quincke, by the change in its optical properties observed by Kerr, and also by the fracture of the dielectric when the field is made sufficiently intense. So that whenever an electromotive force acts on a dielectric it produces a change in its structure which we shall always speak of as polarisation. This, strictly speaking, has only been directly proved for electromotive forces produced by charges of statical electricity; but, unless we are prepared to say that the electromotive force due to statical electricity is in some way different from that due to a changing current, we must admit that when an electromotive force of the latter kind acts on a dielectric it polarises it. And we are not without experimental evidence that the electromotive force due to variations in the vector potential does produce some of the effects of the electromotive force due to a charge of statical electricity. Rowland's experiments have shown that a moving electrified body will set a magnet placed near to it in motion. It follows from this, by dynamical principles, that if we have the charged body initially at rest and move the magnet it will, if no other forces act upon it, be set in motion; so that in this case there is an electromotive force due to the motion of the magnet, *i.e.*, the variation in the vector potential produces the same effect on the electrified body as the electromotive force due to a charge of statical electricity. For this reason we shall suppose that the electromotive force due to the variation in the vector potential always produces effects on a dielectric on which it acts of the same type as those which have been observed to arise from the action of an electromotive force due to a charge of statical electricity. Let us now consider a magnet surrounded by a dielectric. If we set the magnet in motion, we produce an electromotive force which polarises the dielectric. Let us, to fix our ideas, consider an element of the dielectric and the magnet. When the magnet moves it polarises the dielectric; it follows from dynamical principles (an extension of the principle of action and reaction),* that if the polarisation of the dielectric be altered the magnet will move, so that a change in the polarisation of a dielectric produces a magnetic force.

Again, let us instead of the magnet consider a coil of wire conveying a current. A change in the rate of flow of the current produces a change in the polarisation of the dielectric; it follows that a change in the rate of change of the polarisation of the dielectric will produce a change in the current, *i.e.*, will produce an electromotive force.

It follows too, from dynamical principles, that as the change in the polarisation of an element of the dielectric due to the change in the current depends on the distance of the element from the current, there must be a force between the current and the element when the polarisation of the latter is changing. Thus we see that a change in the polarisation of the dielectric must produce all the effects of an ordinary conduction current, so that it is only absolutely necessary to consider how the experimental evidence affects those theories which take the action of the dielectric into account. As, however, the experiments which have been made are few in number, and are all concerned with interesting points, we shall consider them in their relation to all the theories, and not only to those which take the dielectric into account.

Schiller's Experiments.

The first experiment which we shall discuss is one made by Schiller, and described by him in Poggendorf's *Annalen*, Vol. CLIX., pp. 456, 537; it was intended to test the potential theries of Neumann and Helmholtz. We saw that, according to these theories, in an unclosed circuit there are, in addition to the forces due to the elements of current, and which are expressed by Ampère's law, forces arising from the discontinuity of the currents at the end of the circuit. If we have an end of a circuit where the current stops, and the electricity accumulates at the rate de/dt, it will exert on an element of current of length ds traversed by a current of intensity i a force tending to the end and equal to

$$A^2 ids \frac{de}{dt} \frac{\cos\theta}{r}$$

where θ is the angle between the element of current and the radius drawn to it from the end. If we calculate from this expression the couple produced by an end on an endless solenoid, or on what is practically the same thing, a ring magnet, we shall find that the couple tending to turn the ring about an axis in its own place will not vanish, whilst the couple arising from the forces given by Ampère's law will. Thus, if the ring rotates, as it should according to the potential theory, it must be from the action of the end.

In Schiller's experiment the end of the current was the end of wire connected with a Holtz machine. This was placed near to a ring magnet which was suspended by a long cocoon fibre; the magnet was protected from electrostatic influences by being enclosed in a metal box connected with the earth. Schiller determined the intensity of magnetisation of the ring magnet and the quantity of electricity passing through the point, and he calculated that if the potential theory were true, he ought to get a deflection of the magnet of about 27 scale divisions, instead of which there was no perceptible deflection.

This experiment shows conclusively that the potential theory is wrong if we neglect altogether the action of the dielectric, and assume the current to stop at the end of the wire. If, however, we take the dielectric into account, the experiment tells us nothing as to whether Maxwell's theory or the more general one is true; for since the current from the Holtz machine is steady, as much electricity flows out from the end of the wires as arrives there; and thus there is really no discontinuity in the current, the only difference being that before reaching the end the current is flowing through copper and after passing it through air. The condition of things at the end of the wire remains steady, and thus the quantities which we denoted by P and Σ vanish.

The experiment might, however, be modified so as to be capable of distinguishing between the theories which take the

* See a paper by the author of this report "On some Applications of Dynamical Principles to Physical Phenomena," *Phil. Trans.*, 1885.

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dielectric into account. For suppose that, instead of letting the electricity escape through the point, we never let the potential at the end of the wire get so high as to allow the electricity to escape; then, if the wire is initially uncharged, the condition at the end will be changing whilst the wire is charging up, and thus Σ will have a finite value; so that if the magnet were sufficiently delicate and remained undeflected, whilst the point was surrounded by dielectrics of all kinds, it would show that Maxwell's theory is correct.

I have calculated the effect which would be produced on Schiller's suspended magnet, and find that it is too small to be observed; as, however, the time of charging up the wire will be very small compared with the time of vibration of the magnet, the effect will be of the nature of an impulse, so that in this case there will be considerable advantage in having the moment of inertia of the suspended magnet small; while, as Schiller arranged the experiment, there was no such advantage, as the thing expected was a steady deflection. Thus, if the ring magnet were retained it would be desirable to make the opening of it as small as possible, retaining the same cross action. I think the arrangement could be made sensitive enough to be deflected if the value of Σ were any considerable fraction of the rate of increase of the electricity at the end of the wire.

(To be continued.)

PROF. FORBES' CANTOR LECTURES.

LECTURE VI.—(Conclusion.)

At the conclusion of my last lecture I stated that I proposed to make an alteration in the programme. I had originally intended that my concluding lecture should have been on the subject of electrical measurement, showing how a system of units has been evolved, each one depending upon the other. This is a most important subject, and I should have been glad that it should have been included in this course of lectures. But the course of lectures was started with a special object in view—that was, of going into all those fundamental principles and laws of electricity which regulate those numerous applications of it which we meet with every day; in other words, to enable those who are not professional electricians to understand what they meet with in the course of their daily lives in the applications of electricity. For this reason, as I announced last week, I intend to change the subject of this, my last lecture, and to review in a sketchy manner some of the most important practical applications of those general laws or principles and discoveries which we have been considering during the previous five lectures. To-day I shall be dealing with the more important of those applications. Amongst those applications I think you will all agree with me that the most important at the present time is the great facility which we have acquired for collecting and converting into power almost unlimited quantities of electricity. This is the result of the invention of dynamo machines. After I have dealt with this subject I propose to say some words about another application which has had a great deal to do with the development of civilisation, and that is the invention of the electric telegraph. In conclusion, I propose to speak of a still later invention, but one which has attained a vast application in the short period of its existence, namely, the telephone. In the development of invention applied to the progress of civilisation there are two essentially different parts to be carried out. There is the grand field of discovery, and in this field of discovery in electrical science no name stands higher than that of our celebrated countryman, Faraday, which has been so often mentioned in these lectures. Secondly, there is the work of the practical inventor who utilises the tools which have been put into his hand by the discoverer, and who applies those tools to evolve practical ideas and turn out inventions which assist the progress of civilisation. Now, I am first going to speak to you about the manner of constructing a dynamo machine, and all I can hope in this sketchy review is to be able to tell you enough about it, so that when you see a dynamo machine running you will be able to appreciate the object of the several parts of that machine, and you will be able to judge to some extent how far those different parts seem to be suitable to fulfil their offices. In my last lecture I showed you the action of this little machine, which was due to Faraday, consisting of a coil of wire, which is capable of rotation round one of these diameters. In doing so it cuts the earth's lines of force—that is to say, it cuts the direction in which the earth's magnetic force is exerted, and whilst it is cutting that direction it is creating a current of electricity in the coil of wire. This is the fundamental notion in the construction of all dynamo machines such as we have at present. Moreover, in this little instrument which I showed you it is necessary to introduce what is called a commutator, to reverse the current at each half revolution of the coil, because, as the coil takes successive half turns, the direction of the current in that coil is reversed, and therefore we must have a commutator to reverse the current going to the external circuit in order to keep the current continually in the same direction in that part of the circuit in which we wish to make use of it. In order to illustrate the principle of the dynamo let me first show you a small apparatus which has been called the electric hammer. It is rather an ingenious apparatus, and I will try to describe it in a few words to you. I have here a vertical tube, with a coil of wire from the bottom to the top. At every five turns there is a separate wire led on to one of these pieces of brass. I think there are fifty of them in all, if I remember rightly. The first five turns are connected with the piece of brass nearest to me, the next five turns with the second piece, and the next five turns with the third piece, and so on. I introduce into this tube a piece of iron; and I have the means of causing any set of these turns of wire round the vertical column to have a current passing in them. The wires from my battery come to these two pieces of wood, and one of them is connected to a strip of metal which just covers ten of these brass pieces on the flat board, so that by moving this hand-piece along the flat board, and making contact with the different pieces of brass, I can send the electric current through any ten of these sets of turns from the bottom of the vertical column right up to the top of it. Thus, if I introduce a piece of iron into the tube which forms the vertical column, then, by making contact and sending the current through this wire, I can suck the iron right up to the top and down again with very considerable force. I will put a piece of paper on the top of the tube in order that you may see the rising of the iron, which will cause the paper to move. [Experiment.] And now you will see the force with which I am able to bring it down. [Experiment.] It creates a very considerable blow. This is a sort of model of an arrangement called the electric hammer. Well now, I was able to show you by means of the galvanometer the direction of a continuous current. The whole principle of the dynamo machine is contained in this apparatus. The modifications which we find in special dynamo machines are merely modifications to increase the power which we derive from the action which is exhibited by this little instrument. If I were to introduce a pole of iron into the centre of a coil which is rotary, the earth's magnetism would induce a considerable amount of magnetism in the iron while the thing was rotating. Much greater intensity of magnetisation would therefore be got by the coil in the course of its rotation with the iron than actually takes place where there is no iron. That is one of the steps which have been taken in the devolution of the dynamo from this simple apparatus. Then again, the earth's magnetism is comparatively feeble. We are able by means of electro-magnets to produce far more powerful fields of magnetisation than that which is produced by the earth. And the second step in the evolution of the dynamo is to produce a more powerful field than the earth's magnetism—in fact, to produce as powerful a field as we can possibly succeed in doing. That is done by causing the rotating part to travel between the poles of a powerful magnet—similar to these. [Shown.] The principal variations which we find in the construction of dynamos depend to a larger extent upon the proportioning of these electro-magnets so as to produce the most intense field possible for the revolving part to travel through. The revolving part is usually called the armature, and the iron part with its coils round it, which produces the magnetic field, is usually called the field-magnet. I will now show you upon the screen in succession a few slides illustrating the progress of the dynamo machine, from this simple apparatus which you have already seen at work, up to the latest types which you can all see at the Indian and Colonial Exhibition and numerous other places. I will begin by showing you the apparatus which was first used by Faraday in order to produce an electric current. Having projected the image on the screen, he continued: This was one of the first ideas of the dynamo. As a dynamo it is not good. I will tell you why, and in pointing out why it is not good you will appreciate the various stages of progress in other machines. There is an electromotive force tending from the centre of this disc, and there is a tendency to complete the circuit either through the external wire or through the mass of metal on the copper disc. The resistance of the copper disc is far less than the resistance of the wires in the external circuit, and consequently the electromotive force which is created in the interior tends to create a circulating current in the disc rather than currents through the external circuit, which are therefore comparatively feeble. The next apparatus which I will show you is one of the first practical means of producing electricity, that invented by Pixii. [Shown.] Here we have an axis with a horseshoe magnet supported upon it, the poles being in the same horizontal plane. Its pole pieces are two coils of wire, with the iron here. [Indicated.] As it rotates it alternately magnetises one of these bobbins with this pole north and the last pole south. The position of these poles is continually inverted as the magnet rotates. You will notice that the current comes down to a commutator which rotates with the magnet, and by means of split tubes fixed upon the axis the direction is reversed at each half revolution exactly as it was in the apparatus of a more experimental kind which Faraday introduced. The next apparatus is very similar in character. This is a Clarke machine, which contains the same parts, although they are somewhat differently arranged. [Shown.] Here you will notice that the horseshoe magnet is fixed in position, and that the two coils of wire are fixed upon a horizontal axis, and revolve upon it. The ends of the wires of these bobbins come to the two opposite parts of the straight tube on the horizontal axis, and springs at the opposite sides of the axis touch the plate at the top, and so by means of that arrangement the current is led away from the springs to the external circuit. The next machine is one devised by Halske for the purpose of intensifying the action, of which I have been speaking, very considerably by using a more conveniently arranged system of field magnets and armature. The armature is not shown in this, because in order to give the maximum amount of magnetism in it the revolving armature must be almost completely surrounded by the pole pieces of the field-magnet. These two parts here [indicated] are connected with the two ends of the wire upon the armature, which is inside, and it tends to reverse the direction of the current in the other circuit exactly in the same way as the other apparatus which I have been showing you. I will show you this commutator on a large scale in order to contrast it with the arrangement which has been produced at a later date, and which is now almost universally adopted for the commutator of a dynamo machine. [Shown.] Some

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dozen years ago Mr. Gramme invented a machine founded upon these great principles that we have been studying, but introducing some important modifications, and the plan he adopted was, instead of taking a single coil of wire surrounding a piece of iron to get the magnetic field, he took a metal ring and wound a wire round it, threading the wire through the ring at every turn. [Shown.] I will now put in the Gramme commutator, and you will be able to see how the connections were made. [Shown.] I will now project on the screen one of the machines of date before Gramme's, but which is of the utmost importance in the subsequent history of the development of dynamo machines. Here you see in Wilde's machine—at the top of the apparatus—a horseshoe magnet with its armature, exactly like Siemens'. Below that we have a much larger machine of the same character, with one difference. The difference is that instead of having a horseshoe magnet we have one of those powerful electro-magnets surrounded with coils of wire. The electricity developed in the first machine is utilised separately and entirely in magnetising the field-magnets of the large machine below. The consequence is that from this little machine we are able to produce an intense magnetic field, and magnetise very powerfully the revolving armature of the lower machine. In this way Henry Wilde showed us how a very feeble quantity of magnetism might be indefinitely increased, for obviously we might employ the second machine to excite the field-magnets of a third, and so on indefinitely. That, I think, has been one of the most important steps in the progress of the evolution of the dynamo. I will now show you a slide representing a machine of great historical interest, though it was never of great importance as a practical machine. This was invented by Pacinotti before Gramme. It is very much of the same type, and you might call it a sort of laboratory experimental Gramme machine before Gramme had applied the principle to industrial applications, and originally worked simply as a motor. This was not intended originally to generate a current of electricity. It was intended to do mechanical power by sending a current of electricity through it. That is one of the most beautiful effects in connection with dynamo machines. It has been found that a machine which produces electricity in an economical manner is at the same time capable of being driven as a motor in an efficient and economical manner. We can either convert mechanical power into electricity by this machine, or we can convert electricity into mechanical power. I will now show you the Gramme ring in the process of its formation. The ring itself is generally made from wire to prevent induced currents being created, as would undoubtedly happen if it were made of solid iron. The section of the battery is shown in this drawing, likewise a series of coils which have been slipped over it. This is the way in which the rings were first made, but as a matter of fact they are not so made now. The ring now is made in contact, and then these coils are wound upon the ring. The two ends of any of these coils are attached to two bars of the commutator, which we have already seen on the screen. Numerous improvements have been made in the construction of the Gramme machine, but this was really the type of armature which first brought about the dynamo machines which are applicable to industrial purposes. I will now show you the field-magnets of the Gramme machine. [Shown.] There are two electro-magnets with pole pieces in the centre of the coils of wire wound round these electro-magnets so as to magnetise the pole pieces in opposite directions, the one being north and the other south. The magnetic circuit is completed by the two iron standards. I have a model upon the table of a comparatively small Gramme machine, and you will see the iron parts as they are before any wire has been wound upon them at all. [Shown.] I will now project on the screen the complete Gramme machine as it was first created on a large scale for the purpose of electric lighting. I will draw your attention to the different parts of it, so that when you are looking at a dynamo machine you will be able to appreciate every part of it. The electro-magnets are at the top and bottom. The pole pieces are masses of iron, and you will notice in the centre of the conductor the ring, which is revolving upon a horizontal axis. The wires from the different coils in the ring are brought down to the commutator, which is a cylinder built up of separately insulated brass bars upon a horizontal axis. Brushes composed of flat strips of wire bear upon these bars of the commutator as it rotates so as to collect the electricity. These are the essential features of the dynamo machine, and when you are looking at any particular dynamo machine you will always be able to see for yourselves which are the field-magnets, which are the pole pieces of the field-magnet, which is the revolving armature, which is the commutator, and which are the brushes, and by studying the differences in these pieces you will be able to appreciate the advantages there are in the different kinds of machines. Here, again, is a Siemens machine, made much on the same principle. Here are the coils of wire about the field-magnets. The pole pieces are placed upon either side of the armature. The armature itself is only visible at its end, revolving about its horizontal axis. The armature in this case does not consist of a ring but of a solid cylinder of iron. The coils of wire go right round the cylinder, and they are connected at the terminals with bars of the commutator in exactly the same way as you saw before, and the current is carried off with the brushes, which press against the bars of the commutator. Next we have a machine totally different in character to the Gramme machine. But here again we see the field-magnets, pole pieces, armature, commutators, and the brushes in the same way, and we are able to identify the functions of each. This is the Brush machine; but I need not go into the details of this machine. The pole pieces are visible, facing each other. The revolving part consists of a ring partly visible to you, and the coils of wire are partly visible to you. The wires pass along this way to the commutator, which is somewhat different in form, but which performs the same functions, and the current is carried away by the brushes in exactly the same fashion as the other machines. I will now show you the machine which was used for lighthouses in days of old. This is the machine of which Faraday said when it was shown to him as the product of his discoveries, "I gave you a baby and you show me a giant." [Shown.] Here is a Siemens alternate current machine driven by a direct current dynamo. This consists of a series of electro-magnets with the poles facing each other, and coils of wire on a wheel revolving between these iron pole pieces. The alternating currents so generated do not require a commutator, but only a collector, which is fixed upon the axis, and consists of two rings which are connected one with one end of the wire, and the other with the other end of the wire, and then the brushes carry off the current which is utilised in the electric light. This is another machine constructed by Edison in 1881. These horizontal bars are electro-magnets. The pole pieces, as you see, are enormous masses at the ends of these bars. The armature is of much greater diameter than that of any we have been examining, but it is constructed on the same principle, being of a solid mass of iron very much like the Siemens machine. Lastly, as I happen to have a drawing of it I will show you the Gordon machine, which is made on the most excellent economic principles. This is one of the most successful from the thoroughly workmanlike way in which it has been made. I have several other things which I wished to show you, but I have taken up longer time in the description of the machines than I had intended. I will now let you see how these machines are applicable for the purpose of converting electricity into a motive power as well as motive power into electricity. I have here a collection of models of different machines—a large number of them—which it will be very interesting to some of you to look at afterwards. I have the Siemens, Pacinotti, Brush, and the Gramme; and I have also some other models of the same type. [Severally indicated.] As to the application of those powerful currents which we were able to develop by means of the dynamo I need say very little. We have brilliant evidence of it before us just now in the glow lamps which are lighting up this room. But I will throw upon the screen an image of the carbon points which are used in the arc lamps, and I wish to draw your attention to one point, and that is the crater in the positive pole.

A positive pole in consequence of that action wears away more rapidly than a negative. You will see that that crater is a most intense source of light, and by directing the crater in a particular direction we are able to illuminate with great intensity any place. In lighthouses, however, they do not use continuous current machines, and consequently there is no crater, and in appearance the two poles, the ends of the carbon, are identical in lamps lit by an alternating current machine. I might draw attention to other appliances which are very useful applications of electricity, such as secondary batteries or accumulators, which are a very perfect form of battery. By sending a current in the opposite direction to that in which they naturally create one, we are able to recover the elements of the substances in the battery, and to reconstitute them so that by means of a dynamo machine we are able to renew the battery as often as we please. I might draw your attention to the brilliant application of induced currents shown by this apparatus—a secondary generator or transformer. We have simply an electro-magnet with two coils of wire round the iron core. An alternate current of electricity is sent through one of these coils, and the second coil is connected with the lamps which are to be lighted. By this means we are able to convert a current of high tension into a current of low tension. The apparatus is one which is bound to be a most important feature in the application of electricity of the lighting of towns. Especially when we go to a great distance there is a great economy effected in being able to use high tension currents—currents with high potential to carry them over a distance. In houses we must have currents with comparatively low E.M.F., and the power that we have of transforming high potential into low potential currents will help us with the distribution of electricity largely in the future. But time is slipping away. I must leave this subject, and go to the second application which has affected the world so much, viz., the application of electricity to telegraphy.

There I have on the table some specimens of the different kinds of telegraph used. One is the needle instrument. If you send a current of electricity through a wire it deflects the compass needle. Thus a motion of the needle to the left first and then by reversing the direction of the current so as to deflect the needle to the right, we have the signal for letter A, and by combining the motions we can make up the letters of the alphabet. You can examine it afterwards. Here is the sounder which is founded upon the principle of the electro-magnet. There is an electro-magnet here with an iron keeper on the top of it. When a current is passing through it the keeper is pulled down, and makes a noise. Some of these sounds are made short and some long. Thus we may be in London, and are able to pass an electric current to Manchester, where the sounds will be received. Here is a Morse instrument, by means of which an electric current works upon the keeper, and directs a roller, and makes marks upon a strip of paper which is driven out by clockwork, and those marks are long and short, and the combination of the long and short ones makes up the combination of the letters, and so an operator in London is able to converse with an operator in Manchester. I have here a very beautiful apparatus, a device of Sir Charles Wheatstone. It is very largely used in this country, and it is the most perfect system of telegraphy that we possess. It is so rapid that it is impossible to send messages by hand quick enough, and the message has to be prepared by punching holes in a strip of paper, the holes in one side of the strip meaning short marks and those on the other side long marks. This punched paper is itself driven at great speed by clockwork, and another piece of clockwork here is driving another apparatus very similar to that which I showed you before. This apparatus is continually working over long distances between England and the provinces at the rate of 300 words a minute, and frequently up to 400 words a minute. The great advantage of this apparatus is that when you have the Queen's speech, for instance, punched out upon one of these strips of paper you can send it through one of these instruments first to Edinburgh, then to Manchester, and the same punched paper will be sent through a number of places in a very short time.

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I will now briefly allude to the principle of the telephone so largely used, but I will only confine myself to-day to speaking of the Bell telephone, the same instrument being used to transmit the speech and also to receive it. The Bell telephone consists essentially of a magnet, with a soft iron terminal surrounded by a coil of wire. In front of this soft iron pole piece there is placed a disc of thin iron. When I speak against this disc of thin iron I cause it to vibrate in accordance with the sounds. Every time I speak it disarranges the magnetic conditions in the neighbourhood of the coil of wire, and we know that when that happens a current of electricity is set up in the wire, and thus every time this disc is spoken against a current of electricity is sent through the coil of wire to a distant station where the other person is listening. Here an exactly similar apparatus is used, and every time that the current of electricity varies either in direction or in amount it varies the attraction of the magnet for the disc of iron, and in proportion to the number of vibrations of the speaker against the disc which he is using, so are the number of vibrations which are listened to by the receiver. Consequently the sounds heard by the man who receives the message are identical in character with those which are spoken by the sender. I have no time to go more fully into a description of the apparatus, but I will simply say that this is one of the most marvellous applications of electricity yet known. It could hardly have been conceived possible that these minute vibrations would be sufficient to create currents of electricity which would go to such a distance. He concluded by giving practical illustrations of the use of the telephone and Mr. Edison's phonograph.

LEGAL INTELLIGENCE.

The Anglo-American Brush Electric Light Corporation v. Crompton.

In the High Court of Justice (Chancery Division), before Vice-Chancellor Bacon, on Friday last, this action came on for hearing. It was a motion for an interim injunction to restrain the defendants from infringing the patent taken out in 1878, and now held by the plaintiff company, for dynamo-electric machines. The defendants denied the alleged infringement, contending that the Brush patent had been anticipated by a previous patentee named Varley; and they sought by a cross motion to restrain the plaintiffs from infringing their patent, which was taken out in 1882, four years after the date of the original Brush patent, to which, however, amendments had been made at subsequent periods, bringing down the date of the patent as now existing to 1885. It appeared that by the invention of Mr. Brush, an American gentleman, a sufficient electric current to render lighting by incandescent lamps practicable was for the first time enabled to be generated. Dynamo machines, consisting of an armature cylinder of coiled copper wire, rotated at a high velocity, in conjunction with highly excited magnets, had formerly generated the required current on either of two principles—the "series" or the "shunt" systems. By the first the wires carrying the current were attached to the end of the rotating cylinder, the electricity thus passing in a circle. On account of the resistance the current thus met with, it was found that the motive power was not constant or sufficient for lighting purposes. By the "shunt" system the wires were attached in the same way, but were so coiled round the magnets that less resistance had to be overcome on the external circuit. Brush's patent, as described, comprised the coiling of both the external circuit and the shunt wires round the magnet, so that a higher motive was obtained.

Sir HORACE DAVEY, Q.C., for the plaintiffs, said that as conflicting evidence had been given on affidavits by eminent scientific men on each side, in accordance with the practice in such cases, the Court would not be asked to pronounce an opinion without seeing the deponents in the witness box, which, of course, could only be at the trial of the action. Accordingly, on condition of the defendants undertaking to keep an account of the number of machines sold by them made upon the compound winding principle of coiling both the shunt and series wires round the magnets, he motion would stand over until the trial of the action.

Mr. ROMER, Q.C., for the defendants, assented to the course proposed, but asked for a counter undertaking from the plaintiff company to keep an account of all machines sold by them made in infringement of the defendants' patent for keeping the potentials constant.

Sir HORACE DAVEY said the books kept by the plaintiff company would of course contain full accounts of all their business.

The VICE-CHANCELLOR ordered the motion to stand over until the trial of the action upon cross-undertakings being given by the defendants and the plaintiff company, the exact terms of the undertakings to be arranged between the parties.

The United Telephone Company v. St. George.

This was an action (tried before Mr. Justice Stirling on Saturday last) to restrain the infringement by the defendant (Mr. A. F. St. George, of 85, Chancery-lane, London), of letters patent No. 2,909, granted from July 30th, 1877, to Mr. T. Alva Edison for "improvements in instruments for controlling by sound the transmission of electric currents, and the reproduction of corresponding sounds at a distance." These letters patent are now vested in the plaintiff company. The plaintiffs allege that the defendant has infringed the patent since August, 1882.

Dr. Hopkinson, Mr. Imray, and other gentlemen, were called on behalf of the plaintiffs, and cross-examined at great length by the defendant, who conducted his own case.

The defendant having addressed the Court and called his witnesses, Mr. Justice STIRLING gave judgment for the plaintiff company, with costs.

COMPANIES' MEETINGS & REPORTS.

Eastern Telegraph Company (Limited).

The 28th half-yearly general meeting of the shareholders in this Company was held on the 15th inst. at Winchester House, 50, Old Broad-street, under the presidency of John Pender, Esq.

The SECRETARY (Mr. George Draper) read the notice convening the meeting, and the report of the Directors, which has been published in *The Electrician*, was taken as read.

The CHAIRMAN said that the revenue for the half-year ended the 31st March had been £341,405, being a decrease of £30,277 as compared with the corresponding period of 1885. It would be observed on reference to the accounts that there was a decrease in the return from their investment in the South African Company of £1,950, that Company, owing to diminished receipts, having been able to pay a dividend of only 6 per cent., as compared with 7 per cent. in the previous year. Their Indian traffic had been fairly maintained, but the traffic to countries beyond India had declined since December last. The chief cause of their decreased receipts arose from the absence in the past half year of political and other events, which in 1885 augmented their Indian and Egyptian traffic to an exceptional extent. The total working expenses had amounted in the half year to £92,244, being an increase of £645 over the corresponding period of 1885. In the past half year, however, were included several items of an exceptional character, which he mentioned. These items came to £1,566. There was also charged to revenue account an amount of £1,788, the cost of duplexing the Zante-Alexandria cable. Excluding these exceptional items the total working expenses for this half year, as compared with the corresponding period of last year, would show a considerable decrease. The general expenses in London had been £8,773, or an increase of £1,156, mainly owing to their having removed to larger and more commodious offices, which they found were absolutely necessary to carry on the business of the Company, grown as it had within the last few years. The working expenses at stations had been £64,439, being a decrease of £2,143. The item "use of patents" showed a decrease of £1,600. The amount written off for depreciation of cable stores had been, in the half year under review, £4,200, against £2,795 in the corresponding period of 1885. They had carried £5,000 to maintenance ships' reserve fund, against £6,000 a year ago. The expenses attending repairs and renewals and laying of cables had amounted in the half-year to £41,637, being £3,178 less than in the same period of 1885. In abstract C, full details of the work done by their ships were given. Numerous important repairs had been effected, and in addition, the "Volta" had laid two new three-core cables across the Straits of Messina, the cost of which had been taken from revenue. A large part of the sum of £41,600, however, was due to the sudden breaking of both their Bombay cables in 800 fathoms during a cyclone. These were now repaired, of course, and in working order. After charging all expenses, including income-tax, providing for interest on debentures, debenture stock, and preference shares, they were enabled to pay a dividend of 5 per cent. with a bonus of 1 per cent., or at the rate of 6 per cent. per annum, and to carry to general reserve fund £70,000, leaving a balance of £4,079 to be carried forward to next account. He thought they would agree with him that upon the whole the accounts submitted by the Directors were very satisfactory. They were making a new departure with regard to rates, arising from the Conference held last year at Berlin. On all sides they heard it said, "Only reduce the rates and you will have a largely increased revenue." The Directors, however, thought that the risk ought not to be entirely with the Company. Governments even were interfering, and trying to get reduced rates. What the Directors were now endeavouring to establish, both at Australia and other parts, was a guarantee of such a rate of traffic or returns as they had been enjoying during the last three years. If they could succeed in that it would be giving practically a guaranteed rate to the proprietors in these companies, and at the same time it would be an enormous advantage to the different Governments and their telegraphing public, because they would be able to reduce the rates to an extent which it would be simply impossible for the Company to do without this guarantee. These negotiations were going on at present with Australia, and although looked upon with some little shyness, he thought that those who represented the colonies and those who had looked carefully into the matter were satisfied that that must eventually be the solution of the question of a reduction of rates. When that occurred the shareholders would practically be enjoying a guaranteed rate of interest upon their shares. He hoped that these negotiations would make such progress as would be very beneficial to the Company by-and-bye. Telegraphy, they might depend upon it, would grow as nations grew, and therefore he had no fear as to the calculations which were made by people who talked about their going back, and their stocks being reduced in value. There was no fear of their going back unless unnecessary and undue competition arose, and that was a matter which they would take as much care as possible to guard against. At the Berlin Conference, as he believed he mentioned last year, an important question arose about Egypt. He went out to Egypt in the spring and saw the Egyptian Government, and he was very pleased to say that that which they had supposed was going to result in a considerable annual payment from the Company to the Government had been entirely set aside. They were therefore in precisely the same position to-day as they were before they went to Berlin; and as they considered their position a very strong one, should the question arise again, if they had to give something, they would also get something in return. He thought that these visits to different Governments and stations abroad were calculated to do good in many ways. All their stations were in the most perfect order, and comparing them with the stations of other

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nations they had reason, as Englishmen, to be proud. On the previous day they received a congratulatory message from the Governor of Sierra Leone, a circumstance which concerned a company with which they were in very close alliance—he referred to the Direct African Telegraph Company. Probably within two or three weeks the whole of that system would be completed, when it would become a feeder for the Eastern system from Lisbon. When the Direct African concession came before the Government there were some remarks made in the House of Commons by a gentleman who was interested in an opposition company, who desired a competing company with Australia. That gentleman admitted that if this Direct African concession were passed, it would be the death blow to his scheme, and as that scheme was perfectly uncalled for and unnecessary, he (the Chairman) was very glad to find that their concession was approved. It had passed through the hands of three English Governments, and he was pleased to find that the Secretaries of the Treasury of those Governments had defended the concession in the House of Commons in a way which must have been very unsatisfactory to those who had challenged it, but very satisfactory to those who were interested in it. He concluded by proposing a resolution for the adoption of the Report, the payment, less income-tax, of a dividend on the preference shares to June 30th, at the rate of 6 per cent. per annum, and the declaration of a dividend of 2s. 6d. per share, and a bonus of 1s. per share, both free of income-tax, on the ordinary shares, making, with previous payments by way of dividend on account, a total payment of 6 per cent. on those shares for the year ended March 31st last.

The VICE-CHAIRMAN (the Marquis of Tweeddale) seconded the resolution, which was carried unanimously.

On the motion of Mr. JOHN NEWTON a vote of thanks was passed to the Chairman and Directors.

The CHAIRMAN, in reply, stated that the Directors took very great pride in the progress and prosperity of the Company, and the shareholders might depend upon it that the Board would do all they could in the future to maintain its success.

The proceedings then terminated.

[We shall publish a full report of this meeting in our next issue].

The Direct United States Cable Company.

Report of the Directors for the six months ending 30th June last, to be presented at the eighteenth ordinary general meeting of the Company, held at Winchester House, 50, Old Broad-street (Room No. 174), on Friday, July 23rd. at 2 p.m.

The revenue for the half year, after deducting out-payments, amounted to £28,445. 0s. 9d., against £36,106. 1s. 1d. (after similar deductions) for the corresponding period of 1885, being a difference of £7,661. 0s. 4d., against the half-year under review, owing to the reduction of the tariff rate, mentioned in the eighth paragraph of this report. The working and other expenses for the same period, including income-tax, but exclusive of cost of repairs of cable, amounted to £15,866. 19s. 7d., leaving a balance of £12,578. 1s. 2d. as the net profit of the half year, making, with £5,967 1s. 3d. brought forward from the previous half year, a total of £18,545. 2s. 5d. For the corresponding half year of 1885 the working expenses and other payments amounted to £17,205. 15s. 11d., thus showing a reduction of £1,339. 16s. 4d. in favour of the present half year. Every possible economy has been exercised in the several departments of the Company's business. Three quarterly interim dividends of ¾ per cent. each, amounting to £27,319. 10s. 0d. have been declared and paid during the financial year, and a final dividend of 2s. per share is now proposed, making, with the three interim dividends, 2¾ per cent. for the year, being a total distribution of £33,390. 10s. The appropriation of the above balance of £18,545. 2s. 5d. on the revenue account is thus shown :—

Interim dividend for quarter ending 31st March, 1886.	£9,106	10	0
Final dividend now proposed	6,071	0	0
Carried to reserve fund	316	13	2
Carried forward to next account	3,050	19	3
	£18,545	2	5

During the current year the reserve fund has been increased by the interest on the investments, profit on sale of security, and sums transferred from revenue account, and now amounts to £325,000, after payment of the cost of repairs. A break occurred in the short section of cable on the 7th February last, and was repaired on the 18th of same month. On the 5th May last the tariff and that of the Associated Companies was reduced to sixpence per word to New York, and by arrangement with the Western Union Telegraph Company this reduction also applies to most of the principal places in the United States of America and Canada. For press news a special rate of threepence per word between London and New York has also been adopted. On the same date the tariff of the Mackay-Bennett cables was reduced to one shilling per word. So far the reduction has resulted in more than doubling the volume of traffic, and the Directors are not without hope that with a revival of trade it may be further increased. This alteration has not, however, developed a remunerative revenue. In the interests of the public and the proprietors the Directors desire to give the experiment such a continuous trial as will afford the commercial community the benefit of a permanent low rate, if it is likely within a reasonable time to yield a return commensurate with the capital employed, and the risks involved, in the establishment and maintenance of the system. Pursuant to the provisions of the Articles of Association, two of the Directors, viz., Admiral R. C. Mayne, C.B., M.P., and Charles Meara, Esq., retire by rotation, and being eligible, offer themselves for re-election. Mr. John G. Griffiths and Mr. John Sawyer, the auditors, retire pursuant to the Articles of Association, and offer themselves for re election.

CRICKET.

CARCAVELLOS C.C. *v.* VICTORIA C.C.

The above match (between the staff of the Eastern Telegraph Company at Quinta Nova, Carcavellos, and a Lisbon club) was played on the "Campo Pequeno," Lisbon, on the 2nd inst. At noon the Carcavellos commenced batting, the first five wickets falling for 23 runs, of which Mr. Bean contributed 12. On Messrs. Woodman and Freeman coming together runs came faster. At 38 Mr. Freeman was run out, after playing a steady game for his 15 runs. The innings closed shortly afterwards for 121. The Victorians in their first innings put together a total of 56, Messrs. Ferrie (16) and Rawston (12) being the highest scorers. Carcavellos in their second innings made 176, Messrs. Woodman, Lovell, and Bean showing up well. V.C.C. in their second innings scored eight runs for the loss of two wickets, when stumps were drawn. Scores :

Carcavellos, *1st innings.*—H. Hitchcock, c. Atkinson, b. Dalrymple, 0 ; H. Bean, b. Dalrymple, 12 ; E. V. Wyse, b. Alexander, 4 ; H. Musters, c. Maclaren, b. Dalrymple, 0 ; L. Woodman, not out, 59 ; F. Le Clair, run out, 1 ; R. Freeman, run out, 15 ; G. Lovell, b. Dalrymple, 0 ; J. Brereton, b. Dalrymple, 0 ; F. Noyes, b. Dalrymple, 9; R. Kidd, lbw., b. Giovetti, 0 ; extras, 21 ; total, 121. *2nd innings.*—L. Hitchcock, b. Alexander, 2 ; H. Bean, b. Dalrymple, 16 ; E. V. Wyse, run out, 5 ; H. Musters, b. Dalrymple, 0 ; L. Woodman, not out, 78 ; F. Le Clair, b. Dalrymple, 12 ; R. Freeman, c. Oram, b. Dalrymple, 3 ; G. Lovell, c. Maclaren, b. Limbert, 21 ; J. Brereton, c. and b. Alexander, 1 ; F. Noyes, b. Dalrymple, 6 ; R. Kidd, c. Maclaren, b. Giovetti, 3 ; extras, 29 ; total, 176.

V.C.C., *1st innings.*—M. Centeno, c. Woodman, b. Noyes, 0 ; R. Alexander, b. Brereton, 0 ; E. Dalrymple, c. Brereton, b Noyes, 0 ; H. Limbert, c. Lovell, b. Noyes, 1 ; T. Ferrie, st. Bean, b. Woodman, 16 ; G. Rawston, b. Brereton, 12 ; B. Oram, lbw., b. Wise, 7 ; R. Giovetti, b. Brereton, 5 ; T. Atkinson, c. Freeman, b. Woodman, 2 ; N. Maxwell, not out, 2 ; C. Maclaren, c. Brereton, b. Woodman, 3 ; extras, 9 ; total, 57. *2nd innings.*—R. Alexander, not out, 0 ; H. Limbert, c. Lovell, b. Bean, 0 ; T. Ferrie, not out, 3 ; T. Atkinson, b. Atkinson, 1 ; extras, 4 ; total, 8.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. JULY 14.		BUSINESS DONE WEEK ENDING JULY 14. Highest.		Lowest.
Anglo-American	32½	33½	33¾		33½
Do. Preferred	54,	55	55¾		54¾
Do. Deferred	10¾,	11¼	11¼		11
Brazilian Submarine	10½,	10¾	10 7-16		10¼ x.d.
Cuba	10½,	11	10 15-16		—
Do. Preference	18½,	19½	—		—
Direct Spanish	1½,	2	—		—
Do. Preference	9,	10	9 15-16		—
Direct United States Cable	9½,	9¾	9 5-16		9⅛
Eastern Telegraph	10¾,	11¼	11¼		10 15-16
Do. 6 per Cent. Preference	14½,	14¾	14¾		14¼
Do. 5 per Cent. Debentures, 1899	106,	109	—		—
Eastern Extension	12⅜,	12⅝	12⅝		12 7-16
German Union	9½,	9¾	9⅝		—
Globe Telegraph and Trust	6⅜,	6¾	6 13-16		6⅝
Do. Preference	13½,	13¾	13 7-16		13⅛
Great Northern	12,	12½	—		— x.d.
Indo-European	34½,	35½	35½		35
Reuter's	6,	6½	—		—
Submarine	200,	210	206½		—
West India and Panama	⅝,	⅞	¾		11-16
Do. 1st Preference	8½,	8¾	—		—
Western Brazilian	6⅜,	7½	7½		—
Western Union 7 per Cent. 1st Mortgage	118,	122	—		—
Do. 6 per Cent. Sterling Bonds	103,	107	—		—

TELEPHONES.

Consolid. Telephone and Maintenance	13-16	15-16	—		—
Oriental	3-16	5-16	—		—
United Telephone	13¾,	14⅛	14⅛		13¾

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	2½,	2¾	—		—
Do. (fully paid)	4,	4½	—		—
Swan	1⅜,	1⅝	—		—
Maxim-Weston	3-16	5-16	¼		—

MISCELLANEOUS.

Telegraph Construction	39½	40½	40½		39½
India Rubber, Gutta Percha, and Telegraph Works	22½	23½	23½		23¼

TRAFFIC RECEIPTS FOR JUNE, 1886.

COMPANIES.	June, 1886.	June, 1885.	Increase.	Decrease.
Cuba Submarine	2,775	3,032	—	257
Direct Spanish Telegraph	1,513	1,343	170	—
Eastern Extension	38,894	37,846	1,048	—
Eastern Telegraph	45,100	41,514	3,586	—
Great Northern	23,600	—	—	—

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NOTES.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 16th inst. amounted to £2,790.

EDISON'S LABORATORY.—It is said that as a direct result of the strikes in New York City, Edison will remove his great machine plant from that city to Schenectady.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended the 15th inst. were £2,681, as compared with £2,554 in the corresponding period of 1885.

ROYAL SOCIETY.—The Electrical Power Storage Company have received the order to substitute a set of direct acting plant and accumulators for the existing alternating current machine in the installation at Burlington House.

THE TELEPHONE IN BELGIUM.—The Ostend district telephone system has, on the Van Rysselberghe plan, been connected with the Brussels central station, so that Brussels and Ostend subscribers, as well as the public by call offices, can inter-communicate.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 16th inst. were £2,209, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY.—This company announce that the coupon on their 6 per cent. debentures due on 1st August will be paid after that date at the Consolidated Bank, Threadneedle-street, London, E.C.

LIGHTING AND HEATING THE NEW YORK STATE CAPITOL.—It is said that the finished portion of the New York State Capitol at Albany has over 30 miles of gas, water, and steam pipes, and that the annual cost of lighting the building (gas and electric lighting) is 20,000 dollars.

INTERNATIONAL SOCIETY OF ELECTRICIANS. — The *Proceedings* of this society are, in future, to contain a chronicle of the work of the month, and all those engaged in pure or applied electrical science are invited to send a note of their work before the 15th of each month.

HOLLOWAY COLLEGE.—Messrs. Verity and Sons inform us that the cables for the electric lighting for the college were manufactured by the Callender's Bitumen and Telegraph Company, and not by the India Rubber and Gutta Percha Company, as mentioned in our report.

THE WESTERN COUNTIES AND SOUTH WALES TELEPHONE COMPANY.—We are informed that this company, at a Board meeting held on the 9th inst., declared an interim dividend on its preference shares of 3 per cent. for the half year ended the 30th June last (*i.e.* at the rate of 6 per cent. per annum).

EDUCATIONAL.—It is stated that a school has been founded at St. Petersburg specially for the study of electrical subjects, and that the student who successfully passes the examinations receives the title of "Maitre en Galvanoplastie." We have M.A.'s, B.A.'s, &c.; perhaps to these will soon be added M.G.'s.

TEMPORARY LIGHTING.—During the last few days the Electrical Power Storage Company have lit Grosvenor House for the Duke of Westminster on two occasions. They also carried out the lighting of the Indian Room at the ball given by H.R.H. the Prince of Wales, on the 21st inst., at Marlborough House.

ANGLO-AMERICAN TELEGRAPH COMPANY.—At a meeting of the Board of Directors of the Anglo-American Telegraph Company, held on the 16th inst., it was resolved to place the sum of £25,000 to the credit of the renewal fund for the quarter ending 30th June, 1886, and to carry forward the balance of revenue account, amounting to £2,400.

LIGHTING OF OFFICES IN THE CITY.—In view of the successful working of several installations of the electric light in the City in conjunction with accumulators, the North British and Mercantile Insurance Company have decided to have their offices lit throughout, and have given the order for this work to the Electrical Power Storage Company, of 4, Great Winchester-street, E.C.

THE ELECTRIC LIGHT IN AFRICA.—The first African city lighted by electricity was not Algiers or Cairo, but Kimberley, with forty-two Brush lamps, each of 2,000 candle-power. The current is also used there for the killing of dogs—a step suggesting the execution of death sentences by the same means, as proposed in America and France by M. Charson, a member of the Senate.

THE CHARGE FOR TELEPHONE WIRES.—At the last monthly meeting of the members of the Bolton Town Council it was stated that an arrangement had been made with the Telephone Company that for each wire attached to any property of the Streets Committee, or to any pole of the same department fixed on land, 1s. per wire per annum would be charged whatever length and number of attachments there might be.

TAUNTON.—We understand that the electric light is giving so great satisfaction that the energetic proprietor, Mr. H. G. Massingham, has decided to double the plant, and has given an order to Messrs. Laing, Wharton, and Down, the agents in England for the Thomson-Houston system, to supply a 30-light machine by September next. The lighting, which we recently described, has now been going for more than three months without a single hitch.

THE ELECTRIC LIGHT V. GAS.—One of the signal services which electricity has conferred on the public has been to lower the price of gas in all places where any serious effort at competition with the latter has been attempted. This fact is abundantly manifest just now in some of the principal towns of the United States and France, where the popularity of the electric light for street lighting is causing the gas companies no end of uneasiness, and inducing them to atone for their errors in the past by greatly reducing their charges.

THE EASTERN AND SOUTH AFRICAN COMPANY. — The seventh ordinary general meeting of this company was held on Tuesday last, John Pender, Esq., in the chair, when, after an explanation of the position of the company, and of several exceptional demands upon revenue, it was agreed to declare a dividend, amounting, with the previous interim dividends, to 6 per cent. per annum, and to carry to general reserve fund £17,000. The cost of the Mozambique-Zanzibar section has been paid out of the general reserve fund.

TELEPHONE EXTENSION AT SWANSEA.—The number of wires which already span the streets of Swansea is very considerable, and shows the stranger at a glance that advantage is now being pretty freely taken by the business portion of the community of the facilities for the quick communication offered by the telephone. The Western Counties and South Wales Telephone Company have recently taken the premises

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in Wind-street as an exchange. This week their first instruments have been got into position and working order.

ELECTRICAL MACHINES.—Messrs. R. E. Crompton and Co have just sent out several very large dynamos. Three immense shunt machines, giving 110 volts and 325 amperes, have been sent to the Small Arms Factory, Enfield; and the firm are supplying the dynamos for lighting up the Surrey residence of the Right Hon. W. H. Smith. They are also making twenty-two sets of machines for the torpedo search lights for the Admiralty, and two machines giving 80 volts and 500 amperes for the Prudential Assurance Company. These machines weigh about 3¼ tons each.

THE ELECTRIC LIGHT IN BUDA PESTH.—The company formed for the construction of Ganz and Co's machines at Buda Pesth has made an offer to instal the electric light in the principal streets and squares of that city. The chief conditions which it demands are:—1st, a concession of ground for the erection of a central station; 2nd, the establishment of water conduits to feed the machinery; 3rd, a concession to work for 20 years, with the right at the expiration of the gas company's concession to supply the electric light to private houses; and, 4th, the payment of a rent of 16 kreutzers per lamp per hour.

THE BRITISH ASSOCIATION.—The British Association having selected Birmingham for the next annual meeting in September, much local effort is being directed towards making the meeting a success to the association and a credit to the town. An exhibition of local industries is to be held in the Bingley Hall, the project having met with so much support that the space at the disposal of the committee of management has all been appropriated, a large number of would-be exhibitors being turned away. The hall, as we have previously stated, will be illuminated with the electric light, partly arc and partly incandescent.

ELECTRICAL ALARM FOR A CABLE ROAD.—In view of the liability of accidents in the running of cable cars the Philadelphia Traction Company is introducing a new electrical system on their Market-street branch. The plan consists in laying leaden tubes containing telegraph wires alongside the conduits, and a simple alarm box will be placed in each manhole along the route of the cable cars. This affords instant communication with the engine-house at Twentieth-street, and when an accident occurs to the cable, necessitating the stoppage of the engine an alarm can be sent at once to the station, and through an arrangement of signals any information that is needed to meet the emergency can be instantly forwarded.

AN ELECTRIC LIGHT SCARE.—Early last week, during an experiment with the electric light at the mills of Mr. J. Walsh, J.P., in the neighbourhood of Blackburn, where scientific knowledge is somewhat behind the times, people from all parts of the town, concluding that the mills were on fire, eagerly rushed in their thousands to the scene of the supposed conflagration. The general alarm soon reached the fire engine station, and a steam fire engine was manned and was soon on its way to the spot, where the firemen no doubt hoped to distinguish themselves in subduing a fire of uncommon proportions. They had, however, proceeded no farther than the police station when they were met and politely informed of the nature of the unusual illumination at the mills.

CREMATION BY ELECTRICITY.—An electrical crematory is said to have been devised by a process described as follows:—The body being shrouded in sheets made of asbestos is laid upon a frame composed of fire brick, while at the head and foot are large copper plates, to which the leads from specially constructed dynamos of large E.M.F. are attached. The body apparently occupies the position of the filament in an incandescent lamp, and upon the current being passed through it would be instantly carbonised, while, as the air would have free access to it the process of destruction, or rather decomposition, would be immediate. The process appears to have the recommendation of great rapidity of action, and immunity from many of the objections to cremation in the ordinary way.

PRIMITIVE TELEPHONES.—The *Scientific American*, discussing this subject, describes and illustrates certain primitive telephones before the era of Bell's patent. In reading these and similar articles, and, in fact, whenever considering information relating to early investigations and designs of apparatus, one thing should be kept clearly in mind, that although from an historical and scientific point of view it is very interesting to have the truth, the whole truth, and nothing but the truth as to the original discoverer and the development of an invention, it is as interesting to know the man or men who made the discovery commercially successful. Returning to the article, it describes a magnetic telephone constructed by A. Holcomb in 1860-61, one by Beardsler of date before 1865, and Van der Weyde's instruments of 1869 and 1870.

LORD NORTHBROOK'S SOIRÉE AT THE COLINDERIES.—On Wednesday evening, after the Exhibition was closed to the public, Lord Northbrook gave a *soirée* in portions of the Exhibition, which were specially illuminated for the occasion by about seven hundred 5-candle incandescent lamps. These required no additional dynamo or engine power beyond the ten Edison and Hopkinson machines made by Mather and Platt for the Edison-Swan Company, two of which, however, are engaged in charging accumulators for lighting the subway and quadrant dining rooms. Under the superintendence of M. Schultz, festoons of white lamps, enclosed in Chinese lanterns, enlivened the tea gardens; a line of red lamps marked out the ballustrade, and green lamps the steps leading to the higher level. The lamps were coloured by simply dipping them in varnish impregnated with Judson's dyes.

A.A.A.S.—These letters are the American equivalent to our B.A. We are apt to speak of the British Association as the B.A., and the meeting as the B.A. Meeting—though it was not to discuss letters that we commenced this note. The B.A. meeting is due within a few weeks, but so far as we know the volume of the *Proceedings* of the 1885 meeting are not yet issued. Some few years back, during the secretaryship of Mr. Gordon, a great and a fairly successful effort was made to issue the *Proceedings* within a reasonable time of the meeting, but latterly the old plan of procrastination has gained ground. However, it may be said that in America they in this case are no better, for the two vols. of the *Proceedings* of the A.A.A.S. for 1884 are but just to hand. If the world depended upon the issue of the *Proceedings* of some of the scientific societies for information as to the progress made, the world would roll upon its axis for a year or so before getting authentic information. Perhaps in this age of hurry our scientific captains take this method of teaching us to "bide a wee and dinna weary."

THUNDERSTORMS.—On Wednesday the Liverpool district was visited by heavy thunderstorms. In the low-lying parts of Liverpool much damage was caused by floods in the basements of business premises. In some cases the city fire engines were employed to pump out the water. The residence of Dr. Wiskin and a cottage in Cobden-street, Heywood, were struck by lightning. The roof of Dr. Wiskin's house was smashed, and the chimney of the cottage was split from top to bottom. The heavy downpour of rain flooded many villages in the district round Kirkby Stephen, Westmorland, and laid hundreds of acres of meadow land under water, inflicting

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great losses on farmers. The Channel Squadron, consisting of the "Minotaur," "Agincourt," "Monarch," and "Iron Duke," with torpedo boats Nos. 23 and 24, which were to have left Queenstown last Monday, are still detained there owing to the severity of the weather. A gale from the south-west is blowing, and incoming steamers report a heavy sea on the coast. At Durham a farm bailiff named Smurthwaite, employed by Messrs. Ferens and Love, colliery owners, was killed by lightning.

DAMASCENING BY ELECTROLYSIS.—A method of damascening by electrolysis has recently been brought out in France. Two copper plates are put into a bath of sulphate of copper solution, one being connected with the positive pole and the other with the negative pole of a battery. A thin layer of insulating varnish or wax is spread over one of the copper plates, viz., that connected to the positive pole, and the damascened device is etched on it. Now, since copper is by electrolysis transferred from this plate to the other plate, it follows that only the lines of the drawing can be attacked. A battery of two cells is sufficient for the pupose. When the plate has been bitten to the depth of a millimetre it is removed from the bath and treated with hydrochloric acid to remove traces of oxide of copper in the lines of the drawing. It is then washed with water, and suspended in a bath of nickel and silver, and connected with the negative pole of the battery. The positive pole now consists of a plate of platinum. The silver or nickel deposits wherever the copper has been attacked, and the depressions are soon filled with the foreign metal; the plate is then polished, and looks like one which has been damascened by hand.

WHO WAS THE INVENTOR OF THE TELEPHONE?—This question has been revived, and has recently been giving rise to a good deal of correspondence in the newspapers, and like all subjects of the kind it will doubtless give rise to a good deal more before it is settled to the satisfaction of everybody. But whoever had the honour of discovering the principle of the telephone, the Italians seem recently to have taken a step which ought to solve the problem for all time. Not content with possessing Galvani, Volta, and Pacchinotti in their niches of electrical fame, they have just erected a statue at Aosta which bears the following significant inscription: — "Innocenzo Manzetti, Inventor and Maker, in the year 1864, of the first Telephonic Apparatus, in occasion of the Inauguration in 1886 of the railway line uniting Italy with the old town of Aosta. The Association of Mechanical Industry and Kindred Arts of Turin." What the Americans will have to say to this in their patronage of Bell, and the Germans in view of the discovery made by Philip Reis at Frankfurt in 1858, may be looked forward to with some interest.

UNDERGROUND CABLES AND HIGH TENSION CURRENTS.—Reverting to the articles which appeared in *The Electrician* of June 18th and 25th upon the subject of the use of high tension currrents with underground cables, it may be of interest to note that the difficulties which were therein referred to do not complicate the problem of electric lighting so much as at first sight would appear. At Nigmegen, recently, the firm of Messrs. William Smith and Co. have completed an arc light installation consisting of ten lamps, fed by underground lead-covered cable, 4,000 metres in length. The cable is protected outwardly by a kind of braiding, while the core (12 strands No. 16) is insulated by several layers of india rubber, manufactured at Silvertown. The wire is laid in the streets at a depth of 2ft., without having any other outward protection. The strength of the current is 18 amperes, with an E.M.F. of from 500 to 600 volts. It would of course be premature to pronounce any decided opinion as to the ultimate results of the use of a cable in this way, but up to the present it has been satisfactory—a state of things which, being so intimately bound up with the future success of the electric light, it is to be hoped will continue.

SOCIETY OF ARTS CONVERSAZIONE.—By permission of the Royal Commission, this agreeable *fête* was held in the Colonial and Indian Exhibition on Friday evening, 16th inst., being one of the two evenings reserved from season ticket holders and the public. The visitors were received in the Indian Court by Sir Frederick Abel, C.B., F.R.S., and the members of the Council. Besides the usual "attractions" of the Exhibition, including Col. Sir Francis Bolton's Art Waterworks, now illuminated by fifteen arc lamps with holophotes, and the Geyser-like effect produced by volumes of steam, the bands of the 1st West India Regiment, of the Grenadier Guards, and of the Royal Horse Guards, discoursed most excellent music, as also did the Criterion Glee Choir and the Royal Hand-bell Ringers. There was no extra lighting in the building, but in the gardens were festoons of 10-candle incandescent lamps, enclosed in Chinese lanterns, which produced a very happy effect. These five or six hundred extra lamps, in addition to the usual number of 11,800, made so little demand upon the four Elwell-Parker dynamos that the accession of resistance was scarcely noticed. On wet nights, however, when there is a considerable leakage, these machines have enough to do to maintain the lighting.

ELECTRICITY AT HATFIELD.—Readers of *The Electrician* need scarcely be reminded of the great practical interest which the Marquis of Salisbury takes in electrical science, for in times past we have frequently had occasion to refer to the excellent installation of the electric light which has been put up at his palatial residence at Hatfield. Amid all the cares of statesmanship and the excitement of party conflict the leader of the Conservative party has yet found some time to devote to the study and practical application of electricity, and perhaps to him is due, more than to any other, the credit of showing to the world the efficiency of the electric light as a household illuminant. A fresh illustration of the uses of electricity and of the undiminished enthusiasm of the noble marquis for making this great force of nature subservient to the purposes of every day life may be found in the fact that it has recently been applied with great success to an ordinary grass cutter. At one of the farms on the estate, it appears, ensilage is being stored in large quantities; and it having been decided to chaff the grass it was necessary to place the cutter some feet above the ground, and now a Siemens motor drives an elevator and the chaff cutter by means of power generated by a Brush machine from the River Lea, a mile and a half distant.

VOLTAMETERS V. ACCUMULATORS.—M. Emile Reynier suggests the use of voltameters of zinc and lead in place of secondary batteries of the Faure type for the regulation of electric lighting. He shows that incandescent lighting direct from dynamos can never be absolutely uniform, because of the inherent irregularities of the driving and generating machinery. These variations are more or less marked, according to the degree of perfection of the installation; and more or less endurable according to the nature of the service required. In the case of lighting by incandescence, small alterations of velocity produce great variation of brilliancy in the lamps; the luminous intensity being nearly proportional to the sixth power of the difference of potential between the two branches of the distributing service. Accu-

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mulators, as is known, render the current sensibly regular, because their electromotive force varies much less than that of the machines which charge them. The great objection to the use of accumulators for this purpose is that the regularity they bestow costs too much. Hence M. Reynier suggests in *La Nature* that for the office of flywheel, as distinguished from that of gasholder, the voltameter may supplant the accumulator. The regulating power of a secondary battery does not depend upon its electro-chemical capacity, but upon its regularity of discharge.

Underground Wires.—The question of overhead and underground wires may be said to have been fought out to the bitter end by our friends across the Atlantic. A few years has sufficed for public indignation to compel the authorities to take effective action. Overhead wires are condemned, and the larger towns will have none of them. The action taken in Chicago and New York is certain to be followed up. Vested interests will count as nothing in America. The order goes forth—"Get rid of your overhead wires, or we will get rid of them for you." What a pity it is we have not some strong hand to do the same thing in London. The supporters of overhead wires have fought gamely in America, and must acknowledge themselves fairly beaten. Chicago and New York have tried lots of systems, and at last have definitely decided to adopt that of Mr. David Brooks. We are glad to hear of this, as since our introduction to the system in 1881 we have ever thought it presented a way out of the difficulty of overhead wires. Mr. Brooks has himself been to Chicago to arrange the work there. The contract with the Bell Telephone Company is for laying about 2,000 miles of wire underground. The work will be begun some time in September and will be completed in about thirty days. The wires will be laid in three trunk lines in three of the principal streets. A three-inch pipe, containing five hundred wires, will be laid, and at every cross street twenty wires will be switched off for the accommodation of the customers along that street. The number of wires will therefore diminish as the distance increases, until, at the end of two miles and a half from the starting point, only 100 wires will remain. These will be put on poles, forming lines to the suburban towns. Mr. Brooks says poles and lines are rapidly disappearing in Chicago itself. There is not a pole carrying electric light wires on the streets, a state of affairs differing very widely from that existing some few months ago.

Heating Foot-Warmers by Electricity.—M. Tomasi, says the *Proc.* Inst. Civil Engineers, has introduced an improvement in the plan for heating foot-warmers for railway carriages with acetate of soda, by causing a current of electricity to pass through the liquid solution in such a way as to produce an increase of temperature, and so maintain the heat lost by radiation. The current generated by a dynamo, driven from one of the axles of a luggage-van, is sent through a circuit which extends from one end of the train to the other, and from this main circuit the branch conductors that pass through each foot-warmer in a longitudinal direction are connected. The foot-warmers, which are previously filled with acetate of soda, hyposulphite of soda, or some other salt of soda, having the property of maintaining a large amount of latent heat, which is disengaged when passing from a liquid into a crystalline state, are before starting plunged into boiling water, and when sufficiently heated, placed in the carriages, and connected with the circuit. When the train is stopping no effect is produced, but as soon as a sufficient speed is attained the electric current, generated by the dynamo, traverses each foot-warmer, and the conductor in it being of less section than the one outside, a greater amount of resistance is offered to the passage of the current, and in consequence heat is produced, and is communicated to the solution, replacing that which has been lost by radiation in warming the vehicle. The quantity of latent heat in the solution being considerable, a stoppage of even three hours is not capable of producing such a cooling effect as to render necessary its being reheated by other means beyond that described; therefore, a train may travel from Calais to any part of Europe without there being any necessity to change the foot-warmers. It will readily be seen from this the great advantage that such a system offers, both to railway companies and to passengers; in the first place fewer foot-warmers are required, a saving in the cost of labour, maintenace, fuel, &c.; whilst, in the second, the comfort of the latter is at the same time increased. A simple arrangement by which the conductor in the foot-warmer is thrown out of circuit, when too hot, provents any danger from overheating.

Electric Traction of Vehicles.—The following, according to the *Revue Internationale de l'Electricité*, is the problem which M. J. B. Berlier has set himself to solve. A good means of transmitting the electric energy by means of conductors running along the road to a light motor placed on the vehicle, this electric energy being produced in a factory at the terminus. This transport of electric energy has its difficulties, as is well known. There must be all along the way two continuous sliding contacts, and it is on their quality and constancy that the progress of the carriage depends. If contact is broken on one of the two conductors the carriage is forcibly stopped. Again, there is the difficulty of leakages, especially with underground lines, and aerial lines supported by posts are objectionable to the eye, so that the underground lines will have to be the ones permanently used where artistic effect is important, as in Paris. For tramways the use of the rails has been suggested, well insulated as conductors, but it is easily seen that in towns, which are the chief centres of these installations, the suggestion is hardly practicable. Passengers and horses are exposed to electric shocks, which are annoying even when not dangerous, and a bar of metal placed so as to join the rails closes the circuit and stops the service. Underground passages, which meet the mass of principal objections, present difficult conditions; contacts with the earth are to be dreaded, and the keeping in working order is difficult. M. J. B. Berlier suggests that the rolling way consist of two hollow cast metal rails; each of these supports two steel rails, shaped in section like mushrooms, leaving between them a longitudinal interval for lodging the flanges of the wheels and the passage of the stalks of the collector of the current and of the scrapers and brooms. The rails are fixed to the upper part and suitably wedged along a cast metal trench which traverses the whole length of the road. It is in this trench, and under the shelter formed by a projecting part, that the conductor is mounted on an insulating support. The mud and dirt of the street which fall into the trench through the groove are driven along by scrapers and brooms to conduits placed at intervals and communicating with the drains. The aim of these arrangements is to prevent the mud from reaching the conductor, and ensure the cleanness of the trenches by flushing. The current arrives at the motor under the carriage by means of a collector mounted on a light frame on the axles, so that its relative height does not vary and contact is insured. The contact piece carries at its lower end a spring or some other arrangement to force the collecting brush to rub constantly against the conductor. The current is brought back to the generator by a similar arrangement on the other side.

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REGISTERING FREE PENDULUM OSCILLATIONS.—M. Marcel Deprez has recently presented to the French Academy a very interesting note upon the above subject. He says: It is well known that the problem of determining the force of gravitation in a given locality is practically reduced to that of obtaining the period of oscillation of a free pendulum. It is therefore a matter of some importance to perfect the means of timing the swing of such a pendulum with the utmost accuracy. The only method which can be employed in practice is to count the number of oscillations during a given period, the pendulum being allowed to swing with absolute freedom. Then the longer the experiment lasts the more accurate will be the result, but at the same time the greater will be the fatigue of the observer. It would therefore be very convenient, if it were possible, to construct an apparatus which should register the number of oscillations, after the manner of the mechanical speed counters, but which should at the same time fulfil the condition *that it should not exert any mechanical action upon the pendulum.* It is evident that this is a problem which can only be solved by the employment of some optical method. M. Deprez proceeds to say that the first idea which suggested itself to him was based upon the employment of a mixture of hydrogen and chlorine, which, under the action of a reflected light ray, produces an explosion at each swing of the pendulum. He did not, however, see his way to the construction of a practical apparatus upon this principle. M. d'Abbadie then suggested that the reflected ray might be caused to fall upon a selenium wire traversed by an electric current. The resistance of the selenium would thus undergo a periodical variation, synchronous with the swing of the pendulum, which variation might without much difficulty be made to control an electro-magnetic counter. This method was not, however, adopted because it was not known whether or not the resistance of the selenium would vary with sufficient rapidity. Finally, M. Deprez has determined to adopt the following plan, which although not yet put in practice, does not seem to present any special difficulty:—It is well known that the action of the thermopile under radiant heat is not only characterised by excessive delicacy, but is also well nigh instantaneous. The pendulum is therefore mounted behind a screen, which is provided with a long and narrow slit in the vertical direction. In front of this slit is placed a "linear" thermopile, consisting of a single vertical row of elements. Upon the same side of the screen as the pendulum is a petroleum lamp with a flat wick. The lamp is placed in such a position that its rays, after traversing a cylindrical lens, fall upon the pendulum, and are thence reflected upon the face of the thermopile. At each oscillation, therefore, a current will be generated in the pile. The current is caused to pass through the coils of a very sensitive but extremely dead-beat galvanometer. The deflection of the needle thus reproduces the swing of the pendulum. The needle is caused to act as the tongue of a relay, and closes the circuit of a more powerful battery, which actuates an electro-magnetic counter. In this way it would be possible to obtain an automatic record of the number of vibrations of a free pendulum during any required period.

AN ENGLISH TELEGRAPH VICTORY.—We congratulate Mr. Thomas Fuller, the managing director of the Brazilian Submarine Company, on the great victory he has just scored in Paris for the English telegraph industries. That company is one of the most prosperous telegraph corporations here. It holds a privilege, which will last seven years longer, of telegraphic communication between Brazil and Europe, and besides propping up the Western and Brazilian Company, to which it hands over one-third of its receipts, it has made money enough to pay 7 and 8 per cent. on the enormous capital of £1,300,000, besides £150,000 of debentures, and to build a duplicate cable, taking for the purpose upwards of £500,000 from the reserve fund. In every respect the Submarine is a strong company, and its shareholders include many strong and influential people. Some time ago an American company, the D. Pedro II., undertook to lay a cable between Brazil and Trinidad, there to connect it with the lines of the West India and Panama and the Cuban Submarine to Florida. But, as the West India and Panama refused any traffic agreement whatever with the D. Pedro II., the latter looked elsewhere for a footing in the Antilles, and found it in San Domingo, where a French company was in possession of a valuable privilege. That company lately proposed to reorganise itself and lay cables to Cayenne, which is now isolated, Martinique, Guadaloupe, Curacoa, and Venezuela, and from San Domingo, directly to some convenient point in the United States. The French Government agreed to guarantee a large sum of money as interest upon the capital, and the Government Bill, signed by President Grévy and three Ministers, came before the Chambers a few days ago. It had been approved by the committee of the Budget, and the Government considered it so important that it asked urgency for its consideration. It must be a matter of congratulation for the Submarine, Western and Brazilian, West India and Panama, and the Maintenance and Construction Companies, that the Chambers by a majority of six votes in 510 refused the urgency. The result is due to the excellent generalship of Mr. Fuller and his French aide-de-camp, M. Despecher, said to be a man of remarkable sagacity, who has certainly made good use of the influence of the four companies at his back, and enlisted in their service the prestige of one of the most respectable of Parisian papers. M. Granet must feel very humiliated, but he deserves no better luck. His scheme is absurd and costly. It is based on the sentimental idea that France must have French cables to French colonies, and should have cables built in France. For that vanity France must pay heavily when the West India and Panama has lines to Martinique and Guadaloupe, and when Cayenne can easily be linked to the British cable in British Guiana. And as to having the cables built in France, it is another sickly "sentimentalism." Our companies have not enough to do, and can build cheaper cables than any new companies in France. The most important of the English companies have made most of the cables of the world, and it is not in vain that their stock is quoted at 150 per cent. and 250 per cent. premium over par value. It is also true that the success of the German factory in Hamburg, which has turned out one of the best cables in existence, the Bennett-Mackay, is a well-assured fact. But all that does not prove that the Société Téléphonique should now embark in an enterprise that is so wholly useless. In the meantime we wish to give a word of warning to our English companies. The Brazilian Submarine has kept up outrageous tariffs for Brazil. Till a few days ago it cost an American coffee merchant 11s. 4d. to wire a word from New York to Rio de Janeiro. The rate is now lower, owing to the cable war and to the lowering of the submarine tariff a few weeks ago, and after the French Government Bill became known. Indeed, up to a short while ago, it cost more to send a message to semi-barbarous Paraquay, 100 miles south of Rio, than to the capital of the Brazilian Empire. No wonder that the Brazilian Government and people detest the English monopoly. The Submarine has certainly killed the French Government Bill, and their contract with Count d'Oksza and his companies; but it should use its great victory sparingly. It should do something for the public. It has already done enough for its enormously-swelled capital.—*The Financial News.*

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ELECTROMAGNETIC INDUCTION AND ITS PROPAGATION.—XXIX.

BY OLIVER HEAVISIDE.

(Continued from page 139.)

Oscillatory impressed force at one end of a line. Its effect. Application to long distance telephony and telegraphy.

Given that there is an oscillatory impressed force in a circuit, if this question be asked—what is the effect produced? the answer will vary greatly according to the conditions assumed to prevail. I therefore make the conditions very comprehensive, taking into account frictional resistance, forces of inertia, forces of elasticity, and also the approximation to surface conduction that the great frequency of telephonic currents makes of importance.

Space does not permit a detailed proof from beginning to end. The results may, however, be tested for accuracy by their satisfying all the conditions laid down, most of which I have given in the last three sections.

The electrical system consists of a round wire of radius a_1, conductivity k_1 and inductivity μ_1; surrounded by an insulator of inductivity μ_2 and specific dielectric capacity c, to radius a_2; surrounded by the return of conductivity k_3, inductivity μ_3, and outer radius a_3. The wire and return to be each of length l, and to be joined at the ends to make a closed conductive circuit.

Let S be the electrostatic capacity, and L_0 the inductance of the dielectric per unit length of the line. That is,

$$L_0 = 2\mu_2 \log (a_2/a_1); \qquad S = c/2 \log (a_2/a_1). \quad . \quad (33b)$$

We have $L_0 S = c\mu_2 = v^{-2}$; if v is the speed of undissipated waves through the dielectric.

Let V be the surface potential of the wire, and C the wire current, or total current in the wire, at distance x from one end at time t. The differential equation of V is

$$\frac{d^2V}{dx^2} = (R' + L'p)SpV; \quad . \quad . \quad . \quad . \quad (34b)$$

where R′ and L′ are certain even functions of p, whose structure will be explained later, and p stands for d/dt. That of C is the same. The connection between C and V is given by

$$-\frac{dV}{dx} = (R' + L'p)C \quad . \quad . \quad . \quad . \quad . \quad (35b)$$

Both (34*b*) and (35*b*) assume that there is no impressed force at the place considered. If there be impressed force e per unit length, add e to the left side of (35*b*), and make the necessary change in (34*b*), which is connected with (35*b*) through the equation of continuity

$$-\frac{dC}{dx} = SpV \quad . \quad . \quad . \quad . \quad . \quad . \quad (36b)$$

But as we shall only have e at one end of the line, we shall not require to consider e elsewhere.

Now, given (34*b*) and (35*b*), and that there is an impressed force $V_0 \sin nt$ at the $x = 0$ end, find V and C everywhere. Owing to R′ and L′ containing only even powers of p, and to the property $p^2 = -n^2$ possessed by p in simple harmonic arrangements, R′ and L′ become constants. The solution is therefore got readily enough. Let

$$\left.\begin{aligned} P &= (\tfrac{1}{2}Sn)^{\frac{1}{2}}\{(R'^2 + L'^2n^2)^{\frac{1}{2}} - L'n\}^{\frac{1}{2}}, \\ Q &= (\tfrac{1}{2}Sn)^{\frac{1}{2}}\{(R'^2 + L'^2n^2)^{\frac{1}{2}} + L'n\}^{\frac{1}{2}}. \end{aligned}\right\} \quad . \quad . \quad (37b)$$

These are very important constants concerned. Let also

$$\left.\begin{aligned} \tan\theta_1 &= (L'nP - R'Q)/(R'P + L'nQ), \\ \tan\theta_2 &= \sin 2Ql/(\epsilon^{-2Pl} - \cos 2Ql). \end{aligned}\right\} \quad . \quad . \quad (38b)$$

These make θ_1 and θ_2 angles less than 90°. Then the potential V at distance x at time t is

$$V = V_0\epsilon^{-Px}\sin(nt - Qx) + V_0\frac{\epsilon^{Px}\sin(nt + Qx + \theta_2) - \epsilon^{-Px}\sin(nt - Qx + \theta_2)}{\epsilon^{Pl}(\epsilon^{2Pl} + \epsilon^{-2Pl} - 2\cos 2Ql)^{\frac{1}{2}}}. \quad (39b)$$

and the current C is

$$C = V_0\frac{(Sn)^{\frac{1}{2}}}{(R'^2 + L'^2n^2)^{\frac{1}{4}}}\left[\epsilon^{-Px}\sin(nt - Qx - \theta_1) - \frac{\epsilon^{Px}\sin(nt + Qx - \theta_1 + \theta_2) + \epsilon^{-Px}\sin(nt - Qx - \theta_1 + \theta_2)}{\epsilon^{Pl}(\epsilon^{2Pl} + \epsilon^{-2Pl} - 2\cos 2Ql)^{\frac{1}{2}}}\right] \quad (40b).$$

Each of these consists of the sum of three waves, two positive, or from $x = 0$ to $x = l$, and one negative, or the reverse way. If the line were infinitely long, we should have only the first wave. But this wave is reflected at $x = l$, and the result is the second term. Reflection at the $x = 0$ end produces the third and least important term.

The wave speed is n/Q, and the wave length $2\pi/Q$. As the waves travel their amplitudes diminish at a rate depending upon the magnitude of P. The angles θ_1 and θ_2 merely settle the phase differences. The limiting case is wave speed $= r$, and no dissipation.

The amplitude of the current (half its range) is important. It is

$$C_0 = \frac{V_0(Sn)^{\frac{1}{2}}}{(R'^2 + L'^2n^2)^{\frac{1}{4}}}\left[\frac{\epsilon^{2P(l-x)} + \epsilon^{-2P(l-x)} + 2\cos 2Q(l-x)}{\epsilon^{2Pl} + \epsilon^{-2Pl} - 2\cos 2Ql}\right]^{\frac{1}{2}},$$

at any distance x. At the extreme end $x = l$ it is

$$C_0 = \frac{2V_0(Sn)^{\frac{1}{2}}}{(R'^2 + L'^2n^2)^{\frac{1}{4}}}(\epsilon^{2Pl} + \epsilon^{-2Pl} - 2\cos 2Ql)^{-\frac{1}{2}}. \quad . \quad . \quad (41b)$$

As it is only the current at the distant end that can be utilised there, it is clear that (41*b*) is the equation from which valuable information is to be drawn.

It must now be explained how to get R′ and L′, and their meanings. Go back to equation (28*b*), section XXVII., p. 89, which is the determinantal or differential equation when dielectric displacement is ignored. We may write it

$$0 = L_0p + \frac{\rho_1 s_1}{2\pi a_1}\frac{J_0(s_1a_1)}{J_1(s_1a_1)} - \frac{\rho_3 s_3}{2\pi a_2}\frac{J_0(s_3a_2) - \frac{J_1}{K_1}(s_3a_3)K_0(s_3a_2)}{J_1(s_3a_2) - \frac{J_1}{K_1}(s_3a_3)K_1(s_3a_2)}.$$

When p is d/dt it is the differential equation of the boundary magnetic force, or of C, since they are proportional. Separating into even and odd powers of p it will take the form, if we operate on C,

$$0 = (R' + L'p)C \quad . \quad . \quad . \quad . \quad . \quad (42b)$$

where R′ and L′ are functions of p^2. To suit the oscillatory state, put $-n^2$ for p^2, making R′ and L′ constants. They will be of the form

$$R' = R'_1 + R'_2; \qquad L' = L_0 + L'_1 + L'_2; \quad . \quad (43b)$$

where R'_1 depends on the wire, R'_2 on the return; L'_1 on the wire, L'_2 on the return, and L_0 on the intermediate insulator. The forms of R'_1 and L'_1 have been given by Lord Rayleigh. They are, if $g^2 = \mu_1 n/R_1$, where R_1 = steady flow resistance of the wire per unit length,

$$\left.\begin{aligned} R'_1 &= R_1\left(1 + \frac{g}{12} - \frac{g^2}{12.15} + \frac{11g^3}{12.28.80} - \ldots\right) \\ L'_1 &= \tfrac{1}{2}\mu_1\left(1 - \frac{g}{24} + \frac{13g^2}{12^2.30} - \frac{73g^3}{12^2.28.80} + \ldots\right) \end{aligned}\right\} \quad . \quad (44b)$$

to the last of which I have added an additional term. The getting of the forms of R'_2 and L'_2, depending upon the return, is less easy, though only a question of long division. I shall give the formulæ later. At present I give their ultimate forms at very high speeds. Let ρ = resistivity, and q = frequency $= n/2\pi$, then

$$R'_1 = \frac{(\mu_1\rho_1 q)^{\frac{1}{2}}}{a_1} \qquad L'_1 = R'_1/n \quad . \quad . \quad (45b)$$

These are also Lord Rayleigh's. For the return we have

$$R'_2 = \frac{(\mu_3\rho_3 q)^{\frac{1}{2}}}{a_2}, \qquad L'_2 = R'_2/n. \quad . \quad . \quad (46b)$$

I express R'_1 and R'_2 in terms of the resistivity rather than the resistance of the wire and return because their resistances have really nothing to do with it, as we see in especial from the R'_2 formula. The R'_2 of the tube depends upon its inner radius only, no matter how thick it may be, that is to say upon extent of conducting surface, varying inversely as the area, which is $2\pi a_2$ per unit length. The proof of (46*b*) will follow.

Now, as regards the meanings. Let us call the ratio of the impressed force to the current in a line when electrostatic induction is ignorable the Impedance of the line, from the verb impede. It seems as good a term as Resistance, from resist.

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(Put the accent on the middle e in impedance). When the flow is steady, the impedance is wholly conditioned by the dissipation of energy, and is then simply the resistance Rl of the line. This is also sensibly the case when the frequency is very low; but with greater frequency inertia becomes sensible. Then $(R^2+L^2n^2)^{\frac{1}{2}}l$ is the impedance. Here R and L are, in the ordinary sense, the resistance and inductance of unit length of lines including wire and return. When, further, differences of current density are sensible, the impedance is $(R'^2+L'^2n^2)^{\frac{1}{2}}l$. This is greater or less than the former, according to the frequency, becoming ultimately less, especially if the wire is of iron, owing to the then large reduction in the value of L′ as compared with L.

Now, when we further take electrostatic induction into account we shall have the above equations (34*b*) and (35*b*), in which R′ and L′ are the same as if there were no static charge. The proof of this I must also postpone. It is the only thing to be proved to make the above quite complete, excepting (46*b*), which is a mere matter of detail. The proof arises out of the short sketch I gave in section XXVII. of the general electrostatic investigation, used there for illustration.

The impedance is made variable; it is no longer the same all along the line, simply because the current amplitude decreases from the place of impressed force, where it is greatest, to the far end of the line, where it is least. The question arises whether we shall confine impedance according to the above definition to the place of impressed force, or extend its meaning. If we confine the use, a new word must be invented. I therefore, at least temporarily, extend the meaning to signify the ratio of V_0 to C_0 anywhere.

It is very convenient to express impedance in ohms, whatever may be its ultimate structure. Thus the greatest impedance of a line is what its resistance would have to be in order that in steady flow the current should equal that arriving at the far end under the given circumstances. It will usually be far greater than the resistance. But there is this remarkable thing about the joint action of forces of inertia and elasticity. The impedance may be far less than in the electromagnetic theory. That is, V_0/C_0 according to (41*b*) may be far less than $(R'^2+L'^2n^2)^{\frac{1}{2}}l$. This is clearly of great importance in connection with the future of long distance telegraphy and telephony.

(In passing I will give an illustration of reduction of impedance produced by inertia. Let an oscillatory current be kept up in a submarine cable and in the receiving coils. Insert an iron core in them. The result is to *increase* the amplitude of the current waves. More fully, increasing the inductance of the coil continuously from zero, whilst keeping its resistance constant, increases the amplitude up to a certain point, after which it decreases. The theory will follow.)

To get the submarine cable formulæ, ignoring inertia, take $L'=0$ and $R'=R$. To get the more correct formulæ, not allowing for variations of current density, but including inertia, take $L'=L$ the steady flow inductance, and $R'=R$. To get the linear electromagnetic theory formulæ, take $S=0$, and $L'=L$, $R'=R$. Finally, using R′ and L′ but with $S=0$, we have the complete electromagnetic formulæ suitable for short lines. Thus $S=0$ in (41*b*) brings it to

$$C_0 = V_0 \div (R'^2+L'^2n^2)^{\frac{1}{2}}.$$

Equations (34*b*) to (36*b*) are true generally, that is, with R′ and L′ the proper functions of d/dt. The solution in the case of steady impressed will follow, including the interior state of the wire. Also the interior state in the oscillatory case.

A great deal may be dug out of (41*b*). In the remainder of this section, however, we may merely notice the form it takes at very high speeds, so high as to bring surface conduction into play, and show how much less the impedance is than according to the electromagnetic theory. Let n be so great as to make $R'/L'n$ small. Then we may also take $L'=L_0$. Then

$$P = R'/2vL_0, \qquad Q = n/v.$$

Also, if ϵ^{-Pl} is small, as it will be on pushing up the speed, we need only consider the first term under the radical sign in (41*b*), which becomes

$$C_0 = \frac{2V_0}{vL_0}\,\epsilon^{-R'l/2vL_0}$$

Take for R′ its ultimate form

$$R' = 2(\mu\rho q)^{\frac{1}{2}}/a,$$

got from (45*b*) and (46*b*), by supposing wire and sheath of the same material and $2/a = 1/a_1 + 1/a_2$.

Then the impedance is

$$V_0/C_0 = \tfrac{1}{2}vL_0 \times \text{exp.}\frac{l(\mu\rho q)^{\frac{1}{2}}}{vL_0 a}$$

where exp. is defined by $\epsilon^x = \text{exp. } x$, convenient when x is complex. Here L_0 is a numeric, and $v=30$ ohms (*i.e.*, when we reckon the impedance in ohms); $\rho=1600$ and $\mu=1$, if the conductors are copper; and $l=10^5 l_1$, if l_1 is the length of the line in kilom.; therefore

$$V_0/C_0 = 15L_0 \times \text{exp. } (4l_1 q^{\frac{1}{2}}/30^4 aL_0)$$

To see how it works out, take $L_0=1$, $a=1$cm, and $q=10^4$; then $V_0/C_0 = 15 \times \text{exp. } 4l_1/300$ ohms.

If the line is 100 kilom., Pl is made $1\frac{1}{3}$, which is too small for our approximate formula. If 1,000 kilom., it is made $13\frac{1}{3}$, which is rather large. $Pl=10$ is large. If it is 500 kilom. then

$$V_0/C_0 = 15 \times \text{exp. } 6\tfrac{2}{3} = 1{,}178 \text{ ohms.}$$

So the impedance is only 1,178 ohms at 500 kilom. distance at the enormous speed of 10,000 waves per second. It is of course much less at a lower speed, but the more complete formula will have to be used if it be much lower.

Now compare this real impedance with the resistance of the line, in steady state, its effective resistance according to the electro-magnetic theory, and the impedance according to the same. The resistance of the line we may take to be twice that of the wire, by choosing the return of a proper thickness, or

$$Rl = 2 \times 500 \times 10^5 \times 1600/\pi = 50 \text{ ohms say.}$$

L will be a little more than $1\frac{1}{2}$, say 1·6, therefore

$$Ln = \cdot 8 \times 2\pi \times 10^4 = 5060$$

so that the linear theory impedance is nearly 5,100 ohms.

But, owing to the high speed, we should use R′ and L′ instead of R and L; here take $L' = L_0 + R'/n$ and

$$R'l = 400 \text{ ohms.}$$

This large increase of resistance is more than counterbalanced by the reduction of inductance, so that the impedance is brought down from the above 5,100 to about 3,500 ohms, the electromagnetic theory impedance; and this is about three times the real impedance at its greatest, viz., at the distant end of the line.

It is further to be noted that the wire and return need not be solid, as we see from the value of R′ compared with R. What is needed at very high speeds is two conducting sheets of small thickness, of the highest conductivity and lowest inductivity; *i.e.*, of copper.

(To be continued.)

NEW ELECTRIC DETONATORS FOR FIRING MINES.

The means hitherto adopted for firing mines present inconveniences more or less serious. Formerly a small funnel or tube filled with powder used to be placed at the mouth of the bore, furnished with a bit of tinder which was set on fire; but too often, some powder being scattered about the mouth of the bore or on the tinder, the mine exploded before the workman had time to escape, occasioning frequent and terrible accidents. Besides, there was always the trouble of making the tubes themselves. Later there came into use the Bickford fuse, which marked a great advance, and was received with a good deal of favour because of the simplicity of its application. Unfortunately it is not free from imperfection. For instance, at the moment of its ignition, which is occasionally difficult to effect, a jet of flame and sparks from 3 to 4in. long is observed; hence the serious danger to mines where there is fire-damp. Moreover, this fuse emits a very disagreeable thick black smoke; but its greatest defect lies in the fact that it is sometimes cut during the violent operation of tamping, which must be done with a good

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deal of force to be efficacious and to avoid blowing out. The fuse may be accidentally cut and rendered useless or ignited prematurely. It has other defects, and is also somewhat costly.

The purely electrical system is superior to any of the preceding methods, on account of the certainty of its results and the advantage which it affords of causing several shots to be fired simultaneously. But it has the drawback of being expensive by reason of the high price of the detonators. Besides, the wire of the latter may also be cut during the process of tamping, which is at least not without danger, since it is effected on detonators containing a combustible composition. MM. Scola and Ruggieri have invented a system of firing mines which obviates the foregoing objections. The Ruggieri fuse, which is the name given to it, is composed of a small tube of pasteboard, A, of conical shape in the exterior, and enclosing a fuse or filament, B, a bit of spun cotton coated with a powder paste. The large end of the tube is stopped by an electric detonator (a mixture of chlorate of potash, saltpetre, sulphate of ammonia, and finely-granulated carbon) of peculiar construction, C, solidly fixed, the ends of which, D D, remain outside. This tube is placed in the cavity left by the boring instrument, being solidly secured after the manner of a spigot in a cask on account of its conical form. The wires D D are attached to a cable with two conductors communicating with an induction machine—from which the current is obtained—the detonator is ignited and fires the fuse contained in the tube. The action is therefore absolute, there being no time lost in uncertainty. In fact, if the fuse,

Fig. 1.—The Ruggieri Fuse or Projectile Igniter.

Fig. 2.—Bore of a Mine charged with Powder, and provided with a Ruggieri Fuse.

Fig. 3.—Dynamite Cap furnished with a small Wooden Cylinder containing the Filament.

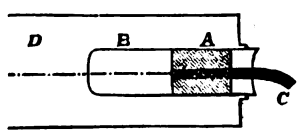


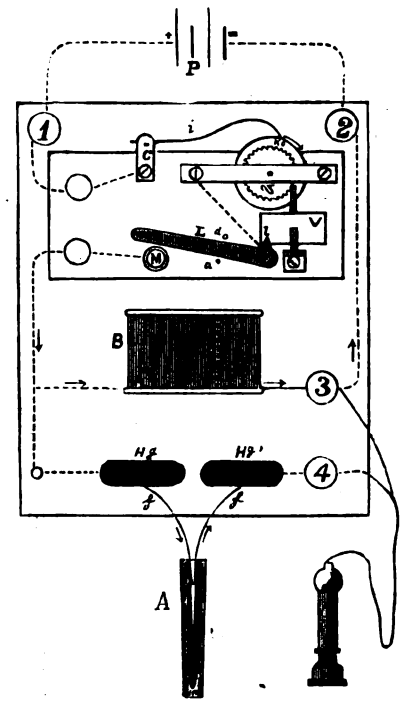
Fig. 4.—Dynamite Cartridge and Cap.

Fig.—Bore of a Mine charged with a Dynamite Cartridge, with Cap, and provided with a Ruggieri Fuse.

although burnt, does not reach the bottom of the bore, as it is composed of an insignificant quantity of material (two or three grains), it is consumed on the way, and leaves only an ash, quite cold in five or six seconds at the most. There is therefore no danger in approaching the shot hole in case of failure, which, however, is not likely to occur, as the detonators are of extreme sensibility. They are during manufacture tested with care by apparatus invented by M. Ducretet, for prompt and easy examination of the detonators by tension, an examination not possible hitherto. To sum up, the Ruggieri fuses obviate the inconvenience of preceding systems. They especially assure to the miners absolute security in consequence of the distance between the charge and the igniter. They do away with flame, so dangerous in mines where there is fire-damp, as well as obviate the loss of time, smoke on account of the minimum of combustible material, and the danger arising from explosive compounds, while their compactness permits of their being easily moved about. Finally, a greater or lesser number may be fired simultaneously according to the strength of the induction machine. In mines charged with dynamite, where there is no need for tamping, the process undergoes a slight modification. In the dynamite cap B A are placed a few pieces of wick or filament, C, leaving one or two centimetres projecting; the top of the copper mounting is flattened, and then the cap is placed in the dynamite cartridge D, which is pushed to the bottom of the hole. There is placed at the mouth of the latter a large stopper of cork or of wood, pierced so that there is an orifice to permit of the admission of the Ruggieri fuse. The wires are attached and the shot is fired. When the fuse ignites it shoots right to the bottom of the bore on to the filament of the cap, which causes the detonation of the dynamite. The stoppers may be used over and over again. MM. Scola and Ruggieri, in order to complete their system of firing, have devised a magneto-electric machine, which by a peculiar arrangement forces a spark of an extra-current to be produced in an enclosed space without communicating with the surrounding air. This machine can, therefore, be worked in an atmosphere impregnated with fire-damp, without causing any explosion through the spark from the machine. This powerful apparatus is constructed with care by MM. E. Ducretet and Co.

APPARATUS FOR TESTING ELECTRIC DETONATORS.

In the manufacture of electric detonators with an interrupted wire designed for firing mines it is necessary, by some rapid process, to be assured before using them of the quality of the



detonators, so as to discard all those the effect of which would be uncertain. To attain this end the detonators must be arranged in such a manner that the spark from the extra current of the electrical apparatus may flash out with certainty in the middle of the combustible material. It is therefore necessary to be sure, first, that the two copper wires are not in metallic contact, which would happen where the protecting covering was taken off; and, secondly, that they are yet sufficiently near so that the sparks may flash out between them. These apparently very delicate conditions may nevertheless be ascertained in the most perfect and rapid manner by means of an apparatus designed by M. E. Ducretet. This apparatus is composed of a battery, P, with three Leclanché cells, from which the current goes through an interrupter with

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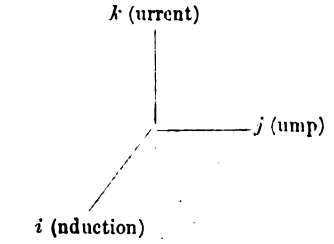
a clock-like movement, R, and afterwards a coil of fine wire, B, and ends in two cups of mercury H*g*, H'*g*. Finally, a telephone, T, is placed in shunt circuit, as shown. When the interrupter is put in motion, and one of the wires of the detonator is dipped in each of the cups, and contact made between the detonator and mercury cups, a rattling noise is heard when there is metallic contact between the copper wires. If, on the other hand, the two wires or the uncharged detonator are absolutely insulated, the telephone is mute; and, lastly, if the detonator is of good quality, a feeble crackling is perceived, resulting from the passage of the electric current through the combustible matter. In the last case the detonator may be considered to be of good quality, and its detonation may be safely relied upon. It is thus easy with this apparatus to examine in a very short time a number of detonators, the resistance of which is above a million ohms, and to ascertain their quality with absolute certainty; detonators tested previously by exact methods with the galvanometer may be used as types to work upon with the telephone. In this connection it may not be without interest to remark that the tests of the platinum wire detonators by means of the galvanometer, such as are employed at the military and naval departments, do not indicate whether the detonator is charged; it might not be so. M. Ducretet's apparatus may in such case be successfully applied, thus effecting a double test, which is of great importance; in other words, in the case of a detonator with an interrupted wire, no sound is heard through the telephone when the detonator is not charged. We have to add that the same machine is adapted for quickly ascertaining circuits of great resistance as well as to verify their insulation.

AMPERE'S RULE.

Again Mr. George M. Minchin, of the R.I.E. College, Cooper's Hill, sends the following ingenious device to our contemporary *Nature* on the subject of Ampère's rule:—"The following version of Ampère's rule is one which I communicated some time ago to a few friends, but it did not appear to me to be expressed in language sufficiently grave to justify its publication. Still, as the rule is a simple and useful one, your readers, in general, may be disposed to overlook its levity.

Draw the three well known Hamiltonian vectors *i j k*. After *i* put (nduction), after *j* put (ump), and after *k* put (urrent), then the figure explains the action of magnetic induction on an electric current. The figure, in fact, asserts that *i* (nduction) in *i* makes *k* (urrent) in *k* to *j* (ump) along *j*.



Of course the same figure gives the direction (according to the law of Lenz) of the current generated by a motion (*i.e.*, a jump) of a conductor in a given direction in a magnetic field in which the direction of the induction is given."

OXIDATION OF IRON BY ELECTRICITY.

The following is the substance of a paper by M. A. de Meritens read before the International Society of Electricians at their meeting on the 7th inst. M. de Meritens began his subject by referring to the misuse of scientific terms and to the discovery of electroplating, and proceeded to show that an ordinary piece of soft iron exposed to the atmosphere easily oxidises in a few days, that pure iron prepared in a laboratory resembles silver in lustre, and takes on a brilliant polish extremely durable, is more elastic than ordinary iron, and possesses a specific gravity of 7·80. He then said: This metal is less oxidisable than ordinary iron; but notwithstanding this circumstance it is attacked in a moist atmosphere, and it is easily dissolved in dilute acid. However much care may be bestowed on its manufacture its condition is not one of absolute purity. He then showed a specimen obtained by electrolysis. Its specific gravity is 8·14. It is almost unoxidisable. Acids at the ordinary temperature exercise hardly any influence upon it. If it is heated to a red heat, and then rapidly cooled, its malleability will be found not to have diminished, while its hardness has not increased. When it is melted the hydrogen which it gives off has not that peculiar odour which is observed in hydrogen exhaled from a solution of ordinary iron. The three metals mentioned differ little in their composition. The difference in the two last are infinitesimal and scarcely appreciable on analysis. And yet the last has almost nothing in common with the other two. It possesses properties and affinities peculiar to itself. Zinc may be placed in the same category. The specimens of galvanised iron which are before you, and which you may examine presently, were kindly given to the speaker in 1876 by M. Jacobi from his laboratory at St. Petersburg. Since then he had never seen better deposits of iron obtained by electrolysis. This was not surprising, however, seeing that it came from the birthplace of electro-deposition. By means of electricity an almost perfect metal was obtained, and what we required was to preserve that metal when in contact with the air. Before touching on the very brief details of the operation it might be useful to glance at the actual industry, and the means of preservation which it employed. The author said that the processes in use for preserving sporting and military gunbarrels from oxidisation by the action of the atmosphere were innumerable.

He then described various of the means adopted for the bronzing of guns, pointing out that the work was not without danger, besides being neither expeditious nor entirely satisfactory. The aim in each case was really to obtain a magnetic oxide Fe^3O^4.

The electric current, he went on to say, must solve the problem, as it had solved that of metallic deposition. The operation was simple and expeditious. The bath was filled with ordinary water, or, better still, with distilled water, heated to a temperature of from 70 to 80 degrees centigrade. The polished piece to be oxidised formed the anode, while a plate of copper, or carbon, or iron, might be used as the cathode. In the speaker's own work he used the sides of the iron vessel as a cathode. The current must have only the E.M.F. necessary to decompose water after having overcome the resistance of the circuit and of the bath.

The operation must be conducted the same way as in electrolysis. Too strong a current produced a non-adherent oxide. There was besides the usual inconvenience of keeping the polished pieces clean in the process. After a few minutes in the bath the polished pieces became black. Magnetic oxide was immediately formed under the influence of the current. After an hour or two's action the layer of oxide Fe^3O^4 was sufficiently solid to resist the action of the scratch brush. It easily took the brilliant polish of the numerous specimens which he exhibited. It had penetrated the pores of the metal. The penetration was even sufficiently deep to give rise to the following effect:—A gun, such as those they now saw, had been oxidised to a brilliant black. He completely removed the magnetic layer by means of emery. The gun became again white. It was dipped afresh into the bath and took on the black again almost instantaneously on the passage of the current. Let them take an old piece of iron exposed to wet for years—it would be covered with a layer of sesqui-oxide of several millimetres in thickness—then place it in a bath of hot water and pass the current. Fe^2O^3 would be entirely transformed to the whole of its thickness into Fe^3O^4. The exterior layer would be non-adhesive. The under layers would be as hard as the iron itself.

During the whole of the first part of his studies on this very interesting subject he had treated only pieces of steel. Sporting or military guns, scabbards of swords, bayonet sheaths were of steel. When he turned his attention to objects made of soft iron, either malleable or cast, an unforeseen difficulty arose. The magnetic oxide obtained with great difficulty had no adhesiveness. On the slightest rubbing it disappeared. He varied the temperature of the bath, and even modified the E.M.F., without success. The hardest steel and most strongly tempered was the metal most easily covered under the action of the current with magnetic oxide, soft iron being the most difficult to treat. It was necessary to find the means to bring it into a molecular condition analogous to those of steel to obtain good results. By the advice of a learned chemist he placed pieces of soft iron in contact with the negative pole of his apparatus after they had been subjected to the action of the current from the positive pole. Taken again to the anode the pieces of soft iron took the magnetic oxide with greater ease and very much greater firmness, but the result was not yet perfect.

He then changed the ordinary water for distilled water, and the work was done to his entire satisfaction. The best of the procesnt in use at the present time, of which he spoke at the commencemsses required not less than from eight to ten days before the operation was complete. The time by the employment of electricity was reduced to as many hours.

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THE NEW FRENCH ATLANTIC CABLE SCHEME.

By a very narrow majority the French Chamber of Deputies has refused urgency for the discussion of a project for laying a new Atlantic cable at the French Government's risk and subsidised by French public money. For the moment the subject is in abeyance; but we may rest assured that the audacity which sprung this extraordinary proposition upon the Chamber will not be cowed by any temporary rebuff, and that, urgent or not urgent, the subject will soon again come on for serious discussion. It is almost too much to hope that anything an English journal can say in opposition to the scheme will influence the decision one way or the other; but none the less is it our duty not to remain silent, especially as English interests are gravely involved in the final decision of the French Deputies. We do not apprehend that English investors will be so foolish as to risk their money in assisting French capitalists to float this new venture; and we are glad to remember that there is at least one Atlantic cable largely owned by Frenchmen who will do their utmost to prevent a wanton and suicidal addition to the competitors now contending for Atlantic telegraph traffic. The English Companies will of course resist it with all their might; but their resistance cannot be very formidable, and in one sense it might even conduce to provoke that national jealousy on which the French promoters will rely in making their appeal for subscribed capital. Nevertheless, as the proposal to lay a fresh Atlantic cable is from every point of view objectionable we ought not to abstain from saying so for fear of being misunderstood. It happens that English interests and French interests are in this relation identical. The idea of a new cable between Europe and the United States is bad, but is neither better nor worse for being a French idea.

So far as can be gathered from the discussion of it in the French Chamber of Deputies, the scheme appears to be to lay a cable from France to the Antilles, thence through French Guiana, and northwards to the United States. Why this devious and hazardous route has been chosen becomes plain when we learn that it is intended to afford a more rapid and independent means of communication for France with her colonies, and "a greater scope for the development of French colonial trade." On the strength of conferring this boon upon the commerce of the French Republic a considerable subsidy, amounting to probably a million francs per annum, for the next twenty-five years is asked for, with a virtual guarantee of the capital embarked in the undertaking. To these conditions the Government appears to have complacently assented, although nothing is publicly disclosed as to the character or personality of the promoters. Whoever they may be they evidently are well acquainted with the one sure way of tapping the national pocket. We may smile at the talk about French colonial development; but it flatters French vanity, and probably by no other method, or for no other route, would money be obtained in France or elsewhere for submerging another Atlantic cable at this moment. It is often asserted that the French Government has fallen into the hands of a band of greedy speculators; and when one sees a scheme of this character solemnly submitted to the Chamber by a Government official the reproach would seem to have some justification. Nobody could legitimately profit by such a cable except the promoters and manufacturers, who are at present unknown; and that any Government should deliberately take it up gives rise to the suspicion that profits of an illegitimate kind are somewhere in the background. M. de la Ferriere gave expression to some misgivings of this kind on the occasion of the motion for urgency; and thanks to his vigorous onslaught upon it the proposition has been adjourned for a while.

Foremost among the pleas put forward in defence of the scheme by the Minister of Posts and Telegraphs was a singular complaint as to the present unsatisfactory state of communication between France and her colonies. This can have reference only to her West Indian colonies; and as communication with them was never more rapid than it is at present, or ever nearly so cheap, it is difficult to understand the argument from either a political or business point of view. The fact that the existing Atlantic cables have doubled, and more than doubled, their traffic within the last three months is proof not only of their capacity for carrying a vast deal more work than has fallen to them in ordinary times, but of their ability to dispose of it expeditiously. Cheap rates would not compensate for slow transmission; and we have reason to believe that the average speed has by no means diminished during the pressure of severe competition. We could at least respect a desire on the part of the French Government to secure a military connection with her distant colonies; but no such motive is put forward, and indeed in this particular case military considerations are almost out of the question, even if they could be served by a cable whose existence, as we have recently shown, would cease directly the necessity for it arose. The development of colonial trade is not dependent on communication by any particular route, and it is hard to see how French commerce would gain by telegrams being sent *vid* the Antilles rather than by the Northern States. The bulk of the cables take the last-named route, and the service of a fresh cable in a different direction would at best be precarious and partial.

The mystery of this French project is greatly enhanced by the circumstance that the existing battle of the rates between the European and American continents has arisen through

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there being too many cables already. For some years past they have been earning small profits, and with the addition last year of two more cables the whole of them ceased to earn any. As a matter of fact there is not enough business to support more than a limited and easily computed number of Atlantic cables, except perhaps at rates which would leave them idle for many hours every day. To add another to the superabundant competitors is therefore an outrage on all business principles, and a gross wrong to the owners of cables already laid. The French Government and the French promoters of this projected new cable to the Antilles cannot be unaware of these notorious facts, and it is pretty evident that commercial considerations of the ordinary kind have not entered into their calculations. It was the easiest thing in the world to prove that a new cable could not pay at the prevailing rates of 6d. per word or thereabouts; consequently a State subsidy would be necessary, and a State guarantee. No better time could have been chosen for the application, but it still remains an enigma how any honest Government could have condescended to listen to it.

CORRESPONDENCE.

NERVOUS FORCE AND ELECTRICITY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to the letter of Mr. Aldred Williams in your last number I am able to say that I have confirmed the results of my previous experiments by holding platinum wire in my own hands, and also by getting the left-handed man to hold the wires in his hands.

As to the sensitiveness of the galvanometer, a current of 13,353 millionths of an ampere will cause a deflection of one scale division. I suppose the average deflection I have obtained would be about 4,000 scale divisions.

It is very important in these experiments to make good contact, because with thin magnesium wire the deflection is uncertain, the needle vibrating indiscriminately; also with very soft lead wire the current seemed to start from my left hand; whereas, when I used hard German silver, the deflections were unquestionably as I described them in my letter to your journal on June 25th. With reference to the experiments with lead wire, I will not attempt to explain the curious results; it strikes me that some very complicated phenomena must have taken place, and if my observations are of any value I hope some explanatory or suggestive remarks may be forthcoming.—Yours, &c., ARTHUR WILLEY.

45, Gladstone-avenue, Noel Park, July 21, 1886.

ON THE SIZE OF CONDUCTORS FOR INCANDESCENT LIGHTING WHEN LAMPS ARE IN MULTIPLE ARC.

BY H. WARD LEONARD.

1st. Size as determined by a required loss of electromotive force in the conductor.

In the various electrical text books and journals there is great dearth of practical information upon this subject. In the principal companies engaged in installing incandescent lamps, most of the *employés* use formulæ for the determination of the circular millage of a wire which depends directly upon the resistance of the lamp and upon some percentage of loss of the total available electromotive force, and which involve the use of a "table of constants," a different constant being required for each candle-power of lamps of the same electromotive force and having the same economy, and also for each variation in electromotive force in lamps of one candle-power.

The writer, after deriving and using quite a number of different formulæ which were steps towards increased simplicity and accuracy, last year derived the formula given below, and its use by himself and others associated with him has been so satisfactory that he has been led to hope that it may be of assistance to some who are at present inconvenienced by the necessity of a "table of constants" which are worthless in case of a variation of candle-power or economy of the lamps they apply to.

Let E = E.M.F. required to bring lamps to nominal candle power.
" C = the current required by lamps in amperes.
" C P = the aggregate candle-power of the lamps.
" C H P = the economy of lamps expressed in candles per electrical horse-power.
" V = the loss of E.M.F. in the conductor both ways, expressed in volts.
" D = the distance to the lamps expressed in feet.
" M = the number of circular millage of the wire.
" R = the resistance of the wire both ways.

Since 1 watt = 44·24ft.-lb. per minute, we have

E + C + 44·24 = the ft. lb. per minute absorbed by the lamps.

Now evidently $$\frac{E \times C \times 44{\cdot}24}{33000} = \frac{C\,P}{C\,H\,P}$$

$$\therefore \quad C = \frac{33000 \times C\,P}{E \times 44{\cdot}24 \times C\,H\,P} \quad . \quad . \quad . \quad . \quad . \quad . \quad 1.$$

Now, the resistance of 1ft. circular mill of copper of 96 per cent. conductivity = 10·725 ohms.

$$\therefore \quad R = \frac{10{\cdot}725 \times 2\,D}{M}$$

By Ohm's law $$C = \frac{V}{R}$$

$$\therefore \quad C = \frac{M\,V}{10{\cdot}725 \times 2\,D} \quad . \quad . \quad . \quad . \quad . \quad 2.$$

Now by (1) and (2) we have

$$\frac{M\,V}{10{\cdot}725 \times 2\,D} = \frac{33000 \times C\,P}{E \times 44{\cdot}24 \times C\,H\,P}$$

Whence $$\mathbf{M = \frac{D \times C\,P}{V \times E \times C\,H\,P} \times 16000}$$

By the substitution of the economy in candles per horse-power, we have a formula of extreme simplicity with but one constant for lamps of one economy, no matter what the variations of candle-power and the electromotive force required may be.

For example, in the case of Edison lamps, which have an ecomony of 160 candles to the electrical horse-power, the formula becomes

$$M = \frac{C\,P \times D \times 100}{V \times E}$$

And it will be noticed that in the case of lamps of 100 volts, which are largely used in the Edison system, the constant vanishes and the formula becomes

$$M = \frac{C\,P \times D}{V}$$

which for simplicity it would be difficult to excel.

From the results of the Franklin Institute test, the constants for the various lamps are given in the table below; as the candle-power of the various lamps was not the same, the mean spherical candle-power is also given.

Name.	Description	Sp. Candles per El. H.-P.	Mean Sp. Candles.	K.	Relative Size of C'nd'ctor Required
Edison	99 volts.	169	15·47	95	45
Stanley	96 "	189	13·59	85	41
"	44 "	216	13·42	74	78
Woodhouse and Rawson	55 " (2nd lot)	210	15·64	76	64
		210	18·30	76	64
White	50 volts.	183	12·44	87	80
Weston, tamadine	110·5 "	210	16·43	76	32
" paper	70 "	166	15·18	100	63

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2nd. On the size of conductors as determined by the heating due to the current.

D = diameter of wire in mils.
M = No. of circular millage of wire area.
C = current in amperes.
R = resistance of unit length of wire.

K', K'', and K''' = constants.

The surface of wire of unit length = π D.
Heat radiated varies directly as π D.
Heat generated varies as C^2 R.
Now R varies inversely as M.

$\therefore$ heat generated varies as $\frac{C^2}{M}$

or $$= \frac{C^2}{M} \times K',$$

where K' is some constant.

Similarly, heat radiated $= K''\pi D$, and since $D = \sqrt{M}$, we have heat radiated $= K''' \sqrt{M}$.

Now, since when the temperature of the wire is constant, the heat generated will equal the heat radiated, we have

$$\frac{C^2 K'}{M} = \sqrt{M} \times K'''$$

$$\therefore \quad M^3 = C^4 \times K$$

$$\therefore \quad M = C^{4/3} \times K$$

and $$C = \frac{M^{3/4}}{K^{3/4}}$$

In practice the only wires of a system of conductors for incandescent lighting which we need expect excessive heating in, are the so-called "omnibus" wires, which carry the total current, and possibly the feeders, which also carry heavy currents.

TABLE A.

Gauge number B.W.G.	Sectional area in circ. mils.	Safe current in amperes.	Circ. mils. per ampere.
	500000	595	822
	400000	503	795
	300000	405	740
	250000	354	707
0000	206116	306	674
000	180625	278	652
00	144400	234	616
0	115600	199	584
1	90000	164	548
2	80656	151	533
3	67081	132	509
4	56644	116	488
5	48400	103	469
6	41209	92	451
7	32400	76	424
8	27225	67	406
9	21904	57	385
10	17956	49	366
11	14400	42	346
12	11881	36	330
13	9025	29	309
14	6889	24	288
15	5184	19	268
16	4225	17	255
17	3364	14	241
18	2401	11	221

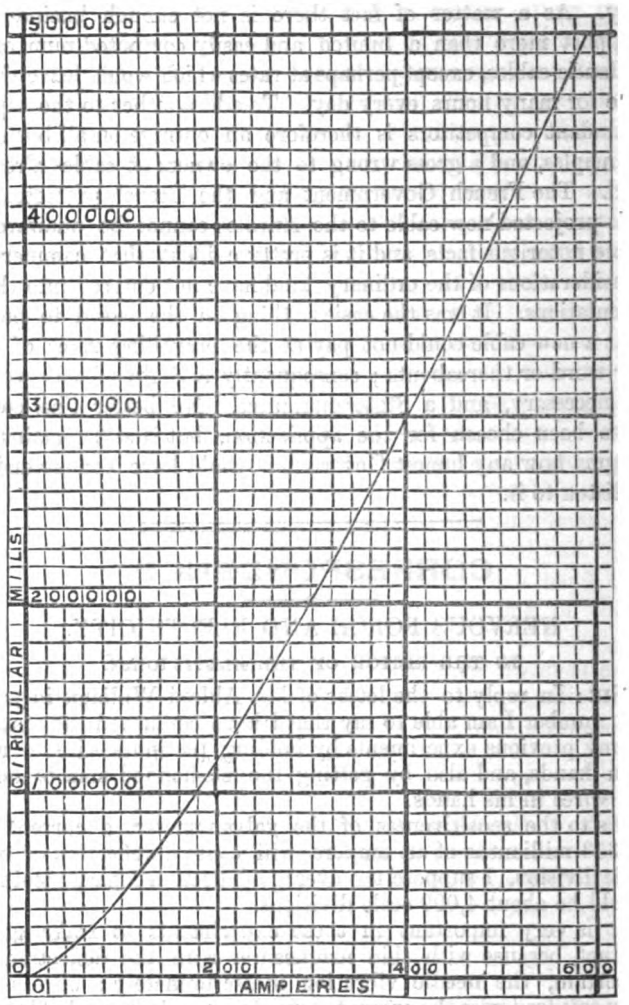
The results of some experiments on bright bare copper wire gave the value 100 for K in the above formula when the temperature of the wire was raised 81 deg. F. or 45 deg. C. That is, for such a rise of temperature as that mentioned the formula becomes

$$M = C^{4/3} \times 100$$

and $$C = M^{3/4} \times \cdot 0316$$

The above formula is applicable to cases when bare or insulated (which latter will be at somewhat lower temperature) wire is to be used and is to have free access to air

Table A gives the data derived from the use of this formula as regards the size of wire for various currents, and a curve plotted from the table is shown below.



Curve plotted from Table A.

In the case of armatures 60° C. is about the maximum safe rise of temperature admissible.

For armatures of the Siemens and similar types, the constant for 60° C. rise is 140. That is, the formula becomes

$$M = C^{4/3} \times 140$$

and $$C = M^{3/4} \times \cdot 02457.$$

Chicago, May 16, 1886.

MAGNETIC RESEARCHES.

BY PROF. G. WIEDEMANN.

(*Continued from page 201.*)

It is also to be observed that the permanent torsions into which the bar, left to itself, slowly passes from the temporary torsions 0° and 210° do not at all agree with the torsions at which it shows the maximum of temporary magnetism; these last lie further away from the extreme torsions than the permanent torsions do.

If we consider the changes in temporary magnetism in the first torsion, we observe in every case an increase and then a decrease, evidently because the molecular magnets, directed more or less axially by the magnetising force, obey at first that force still further in consequence of vibration, and are then carried from their axial position into more oblique positions. This is confirmed by the fact that with very strong temporary magnetism the first rise through vibration is less than with less powerful magnetisation, since in the first case the molecules are already more nearly in the axial position.

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With permanent longitudinal magnetisation the directing force of the external magnetising power is absent; the molecules, disregarding mutual action, are affected only by the displacements produced by torsion, which consequently manifest themselves more distinctly than in the previous experiments. The moment at the limiting-points is different, and thus also the position of the molecules. But again, the most rapid rotation of the molecules at the beginning of each deformation is seen within the given limits.

A similar behaviour is observed in the case of temporary transverse magnetisation, in which the magnetic directing-force which acts upon the molecules is one-sided; and so the moments at the limiting-points cannot be equal. Nevertheless, the rotations of the molecules with rising and falling torsion here also preserve the above-mentioned character.

V. In exact analogy with the mechanical and magnetic behaviour described in Section 4, it may be shown that if a wire which has been subjected to a temporary deformation (as a special case, this deformation may be zero) then suffers another deformation, the molecules again retain the position corresponding to the first deformation up to a certain degree.

In order to make these experiments, a wire was temporarily twisted by forces 0, a, b, gradually increasing, and its temporary torsion measured, as also with decreasing forces b, a, 0. For this purpose the same apparatus was used as in my former experiments. A flat weight $\gamma\gamma_1$ provided with a hook was attached to the thread $o\,q$ which acts upon the torsion circle; to this a second weight $\beta\beta_1$, with a hole through the centre, was attached by lateral threads $\alpha\beta\gamma$, $\alpha_1\beta_1\gamma_1$. These threads were connected to a horizontal wire $\delta\epsilon$, which was soldered to the frame of a pulley η suspended by the thread $\zeta\theta$. The end θ of this thread was attached to a fixed hook, the end $\zeta\theta$ passed over a fixed pulley to the windlass z. If by turning ζ the pulley η was gradually lowered, the weight $\gamma\gamma_1$ at first acted upon the torsion circle until the weight $\beta\beta_1$ reached the other, when both together acted in twisting the wire. The horizontal wires soldered to the weights rested against fixed vertical wires, and so prevented the turning of the weights with the threads carrying them. By winding up the pulley η, the torsion corresponding to the weights $\beta\beta_1+\gamma\gamma_1$ and that corresponding to the weight $\gamma\gamma_1$ alone could be determined. The weights were always raised and lowered very slowly, so that they produced their effect without any jar. The reading each time was not taken until, after putting on the weights, the temporary torsion did not perceptibly change any more. The weight $\gamma\gamma_1$ (1) weighed 61·8 gr, $\beta\beta_1+\gamma\gamma_1$ (1)+(2) 125·9 gr.

As before, the torsions were read off by means of a telescope in a mirror, which was attached to the lower clamp of the wire subjected to torsion, and in which the image of a semi-circular scale, placed round the wire as axis with a radius of 1 metre, was reflected. The following tables contain some of the results obtained. The first column gives under G the weights used to produce the torsion, the following columns give the corresponding torsion successively obtained. The experiments were continued until the same torsion was obtained upon renewed action of the weights.

I. Brass wire, 2 millim. thick and 51·8 millim. long, stretched before loading by a weight of 8350 gr., and annealed under a load of 8000 gr.

G.	I.	II.	III.	IV.	V.	VI.
0	0	223·5	242·5	255·5	264·2	267·3
(1)	684·0	904·5	924·5	937·0	943·0	947·0
(1)+(2)	1691·7	1705·0	1706·7	1713 5	1714·0	1714·5
(1)	973·0	989·5	693·5	990·5	1000·5	1001·5

G.	VII.	VIII.	IX.	X.	XI.
0	269·5	273 0	273·0	275·0	281·0
(1)	949	950·5	952 0	953·5	957·2
(1)+(2)	1714·5	1714 5	1718·5	1719·5	1721·5
(1)	1002·5	1002·5	1005 0	1004·3	1000·5

After ten repetitions of the increase and decrease the deflections obtained were :—

G.	XXI.	XXII.
0	.....	287·5
(1)	.....	965·7
(1)+(2)	1717 8	.....
(1)	1000·5	.....

A similar wire annealed while loaded with the stretching weights gave the following values :—

Torsion.

G.	I.	II.	III.	IV.	V.
0	0	232·5	250·2	262 0	266·5
(1)	701·3	928·5	947·5	962·3	—
(1)+(2)	1711·5	1723·7	1736·5	1733 7	—
(1)	982·5	990·5	999·5	999 0	—

After action of the weights, repeated ten, twenty, and thirty times, the deflections were :—

G.	XXV.	XXXV.	XXXVI.
0	274·0	276·0	276·0
(1)	976·5	975·0	976·0
(1)+(2)	1731·5	1729·5	1729·5
(1)	996·7	999·0	997 0
0	274·5	276·0	276·0

Next the wire was caused to vibrate strongly so as to emit a musical note by striking it with a flat board whilst loaded with the weight (1) during the increase as well as during the decrease of the weights, and also whilst loaded with the weights (1)+(2). The values thus obtained are given within brackets, against the values obtained before the vibration :—

G.	XXXVII.	XXXVIII.	XXXIX.	XL.
0	276·0	292·5	391·5	419·5
(1)	977·0 (984·5)	988·7	1092 (1095·5)	1121·5
(1)+(2)	1738	1746·0 (1861·5)	1853·5 (1890·5*)	1880·5
(1)	1000·5 (1007·5)	1120·5	1150·5	1145·5
0	292·5	391·5	419·5	420·5

* Made to vibrate powerfully and for a long time.

It follows from these experiments that the temporary torsion of the wires, produced by the smaller weight after the action of the greater weight, with a decreasing load, is in every case greater than that produced by the action of the same weight with increasing load, and before the action of the greater weight. The behaviour is observed not only during the accommodation of the wire, but also after it has attained a permanent condition, when a repetition of the cycle of experiments gives the same results. It also is not altered by strong vibration of the wire.

(*To be continued.*)

SELECTED CORRESPONDENCE.

[The following correspondence has appeared in *The Times* on the question of Judges and Patents. It arises out of the late telephone trial. The first letter given called forth a leader in *The Times* upon the subject.—Ed. *E.*]

The very wide experience of Mr. Imray, past President of the Institute of Patent Agents, as a professional expert in patent litigation gives unusual value to the views which he has put forth in the reply which he gave in your columns of July 7. I have, indeed, in one or two cases been subpœnaed as a scientific witness; had I not been, I should probably not have seen so much of the evil practice to which I have drawn attention, and which has of late been the subject of much unpleasant comment in the technical journals. But my experience is nothing as compared with that

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of Mr. Imray; hence I hail as of peculiar value his contribution to the question of the judicial warping of patents.

Mr. Imray, in his capacity as a professional expert, now lays down the whole duty of the Judge in a manner which I believe is quite borne out by the actual recent practice of the Courts. He is referring specifically to a certain patent taken out by the American electrician Edison, and he says: "In such a case Judges *who know their duty*"—the italics are mine—"do not tie down the invention to the precise details given by the inventor; they look for the principle on which the invention is based." That would, I take it, be entirely fair if the inventor had discovered, stated, and claimed the principle on which his invention is based. But, unfortunately for Mr. Imray and for the example in point, the inventor in this case has particularly and in terms thrown aside any claim to the general principle. The claiming clause of the Edison specification is preceded by an emphatic statement that the inventor observes in conclusion that he does not claim the general principle, which in fact was old and publicly known at the date of his patent. Mr. Imray's statement therefore amounts to this—that a Judge who knows his duty (the phrase is a useful one) will give the inventor that which the inventor has expressly disclaimed. Mr. Imray's statement clearly confirms my contention that there exists a judicial practice of patent warping—a practice which is essentially unjust. But Mr. Imray's letter is still more informing as to the part played by experts in misleading Judges. Though he is angry with me for saying that such things are done, he is so kind as to furnish me with a typical example. He declares that Edison's invention was not a mere improvement in constructive details or in combinations. Now there is only one claim in the Edison specification, and it reads thus:—"but I claim as my invention, in an instrument for transmitting electric impulses by sound, *the combination* with a diaphragm or tympan of electric tension regulators, &c." Mr. Edison, inventor, claims as his invention a combination; Mr. Imray, expert, declares that it did not consist in combinations. Which is right? Is this the kind of evidence that Judges are accustomed to get from experts? Will Mr. Imray swear in court that Edison's sole claim does not consist in a combination?

Lastly, Mr. Imray says that Edison's telephone patent is a "new invention" of a "fundamental" character, an "altogether novel departure," and that it is *in such a case* that Judges who know their duty do not tie down the invention to the precise details given by the inventor. It is not self-evident why a Judge should be so unjust as to give to a patentee a monopoly over more than his patent entitles him to, even if he were the discoverer of an absolutely new departure in invention. But, in this instance, Mr. Imray knows as well as I do that Edison's own specification states that the patent is for "improvements"—improvements on the telephones that had gone before; that the patentee was given by his employers a description of the earlier instruments as a basis on which to improve, and moreover that the "new invention" was of so very "fundamental" a character that it was of no practical use until after the subsequent invention by Hughes of the microphone. Yet Mr. Imray urges this "fundamental character" as the reason why Judges should not tie down the inventor to the precise thing that he has invented! In other words, let an eminent expert bamboozle the Judges into thinking that a mere improvement is a great and new invention; let him swear as an expert that a mere claim to a specific combination is a claim to a general principle; then the Judges "who know their duty," as laid down in the ethics of the Past President of the Institute of Patent Agents, will do it. I take Mr. Imray's letter as furnishing a singularly apt illustration of the way in which Judges "are misled by counsel and expert witnesses to such an extent that they quite misunderstand patent specifications, and consequently give unjust judgments." That is precisely what occurred in the recent case of the United Telephone Company *versus* Bassano, at least as regards those issues of Mr. Justice North's judgment which were not confirmed by the Court of Appeal, and also, if *The Times* report of the proceedings of the Court of Appeal be correct, in the stretching by Lord Justice Cotton of Edison's specification so as to include in it things that were invented a year afterwards by Hughes And there are various other recent cases—notably the gas engine decisions—in which a similar judicial warping of patents has occurred. SILVANUS P. THOMPSON.

City and Guilds of London Technical College,
Finsbury, July 12.

Except in response to a virtual challenge, I should not trespass on your valuable space, but the letter from Prof. Silvanus Thompson which you published on Saturday and your leading article on the question raised by him call for some reply, which I will endeavour to make a brief one.

In my former letter I said, or intended to say, that, in dealing with an invention of a fundamental character, Judges properly give a wider interpretation to patent claims than when they have to deal with mere improvements in the details of known inventions. When Watt made the steam engine a success by condensing steam that had done its work in a vessel separate from the cylinder in which fresh steam had to perform work, his patent was upheld, not for any particular form or construction of condenser, nor for any particular mode of condensing, but simply for the separation of the condensing vessel, whatever it might be, from the working cylinder. It was a new idea or a new principle, and it has been properly held that when there is such an idea embodied in an apparatus or process that can be copied or followed with advantage, a patent may be taken for the embodied principle. If it be true that Edison's telephone transmitter is such an embodied principle, Judges, in determining the scope of his claim, however it may be expressed, cannot but have regard to the fundamental character of the invention.

But, taking the language of Edison's claim as it stands, it admits—nay, calls for—the wide interpretation that has been given to it. Before the date of his patent, it was well known that diaphragms or tympans, indeed objects of all kinds, vibrate in obedience to sonorous pulses, converting variations of aerial pressure into minute mechanical movements. It was also known, but not very generally, that carbon, a substance such as Edison calls "a semi-conductor," when subjected to various degrees of pressure or compression, undergoes variations in its conducting power, and can therefore be made to act as what Edison calls "an electric tension regulator." But, until Edison showed the way, no one thought of introducing into a closed electric circuit, as part of the conductor, such a tension regulator, arranged in connection with a "tympan or diaphragm," in such a manner that sonorous vibrations, by altering the resistance of the circuit, produce electrical undulations, which, acting on a distant receiving instrument, reproduced the original sounds. It is this "combination with a diaphragm or tympan of electric tension regulators" acting in this way for this purpose that Edison claims. The idea once given, it is easy to contrive varieties of diaphragms or substitutes for them, it is easy to vary the form and construction of tension regulators, it is easy to make the combination appear very different from anything described by Edison; but, so long as "in an instrument for transmitting electric impulses by sound" there is the combination of something that vibrates to the voice and by its vibrations acts on something which "varies the resistance in a closed electric circuit," that instrument is obviously within the scope of Edison's claim.

Prof. Thompson accuses a Lord Justice of "stretching Edison's specification so as to include in it things that were invented a year afterwards by Hughes." The Professor alludes to the microphone, but he forgets to call attention to a passage in Edison's specification which the learned Lord Justice had before him, thus:—"In some cases I make use of a variable resistance resulting from greater or less intimacy of surface contact, such as would result from a disc covered with plumbago placed adjacent to a diaphragm also covered with plumbago or other semi-conducting material, so that the proximity or extent of surface contact will produce rise and fall of tension, the respective parts being in the telegraphic circuit." What is the microphone but an instrument in which "semi-conducting material" is arranged in a "telegraphic circuit" in connection with a "diaphragm," so that there is "a variable resistance resulting from greater or less intimacy of surface contact," produced by minute vibrations of the diaphragm?

Prof. Thompson does not confine his accusations to one particular case or set of cases; he alludes to "various other cases, notably the gas engines decisions, in which a similar judicial warping of patents has occurred." If it were my business, which it is not, to defend either Judges or experts, I should decline to meet broad sweeping assertions such as that which I quote. When the learned Professor thinks proper to formulate his plaint, as to a certain extent he has done in respect of Edison's patent, it may be possible to answer him. In the gas engine cases I have borne a part, and probably the Professor, looking on from outside, could see how far my conduct as an expert contributed to the "judicial warping" of which he complains. If I have sinned, it has been in good company, and the decisions arrived at, unpalatable as they may be to Prof. Thompson, seem to indicate that those with and for whom I have acted were not altogether in the wrong. To one rule I have always strictly adhered—a rule which Prof. Thompson must, I think approve—never to act as expert when I have any interest whatever in the invention litigated, or in any rival invention.—I am, sir, yours obediently, JOHN IMRAY.

28, Southampton-buildings, W.C., July 19.

The correspondence in your columns on the above-mentioned subject, and your leading article in *The Times* of the 17th have raised a question of importance. There are not many leading counsel who add to their professional ability the power of mastering thoroughly the scientific facts upon which they are "coached" for the occasion—there are very few who have the technical knowledge necessary to deal effectively with the unexpected issues which may arise—in a complicated patent case. In electrical controversies (say a telephone patent case) there are also comparatively few scientific gentlemen of eminence who are experienced in putting their views clearly before the Court. It has now been alleged (both in *The Times* and in many technical journals) that in such a suit the more wealthy of the two parties (the one may be a company with a capital of a million, the other a struggling mechanic or instrument maker) is generally found to have retained by means of a general retainer all the leading counsel who have distinguished themselves in electrical patent law, and that they, with the aid of the most experienced scientific experts available, succeed in misleading the Judges by causing them "to misunderstand patent specifications, and consequently to give unjust judgments."

I am not competent—few men are—to decide whether this has or has not been the case; but Judges, counsel, and scientific experts will agree with me that it is impossible to expect from our Judges that intimate knowledge of scientific details which will enable them always to put a right value upon the intricate technical arguments of counsel and witnesses. For this reason it has been decreed that the Court at its discretion may, and at the request of either party to a patent suit shall, appoint an assessor to assist the Court in this very matter.

Why, Sir, is this never done? It is possible that the Judge does not use his rights from a false feeling that such action might be taken as a confession of weakness, and that neither party does so for fear of incurring the odium of seeming to impute incompetency to the Judge before whom the case is to be heard. As a matter of fact, any want of scientific knowledge must obviously be apparent when a non-scientific Judge discusses difficult scientific points without assistance (as in the judgment on the late telephone case where the Judge asserted that a billiard ball in falling on a table "flattens itself to half its diameter"). If the publicity which you have given to the matter should help to dispel false sentiment and lead to the appointment of assessors in those technical cases, which are often difficult even to technical men, the

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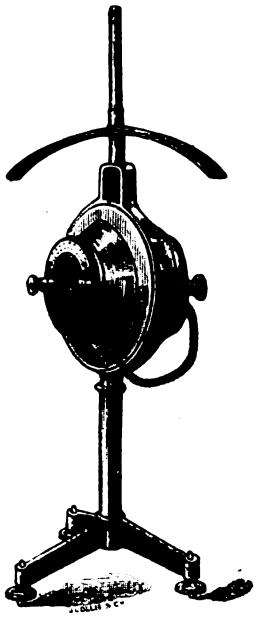
public, who, rightly or wrongly, have expressed dissatisfaction, would feel greater confidence in the administration of the Patent Laws.—Yours faithfully,

GEORGE FORBES.

34, Great George-street, West minster.

NEW REFLECTING GALVANOMETER.

We illustrate herewith a new and most inexpensive form of reflecting galvanometer, made by Messrs. Woodhouse and Rawson. The frame consists of a brass disc, supported on a pillar and ordinary tripod, and surmounted by a rod on which the controlling magnet slides up and down, and in the bottom of which the milled head fibre suspension moves. This disc is turned out on both sides, leaving the centre only one-sixteenth of an inch in thickness, and has a thin slot in it extending from the top to the centre ; this slot takes the fibre, and is enlarged at the centre to allow the mirror and needles to swing freely. The coils, which are wound, and made into a solid block by soaking in paraffin wax, are contained in two brass cases of the form necessary to give the greatest effect upon the needle ; these fit into the turned recesses, and are held against the frame plate by two screws. Two terminals are attached to the ebonite plate which closes the outside end of each coil case, and two glass discs are cemented at the inside end of the axial hole in the coils if a damped instrument is required. The coils can be wound so as to have both their resistances and magnetic effects equal, and the instrument is thus specially suitable for use as a differential galvanometer. Its construction renders the putting in of a new fibre an extremely simple matter, and enables the manufacturer to send out with it any desired number of pairs of coils of different resistances, which can be exchanged one for the other almos instantly. The instrument, while cheap, is



really capable of doing most of the work of much more expensive instruments.

AN ELECTRICAL "IN" OR "OUT" INDICATOR.

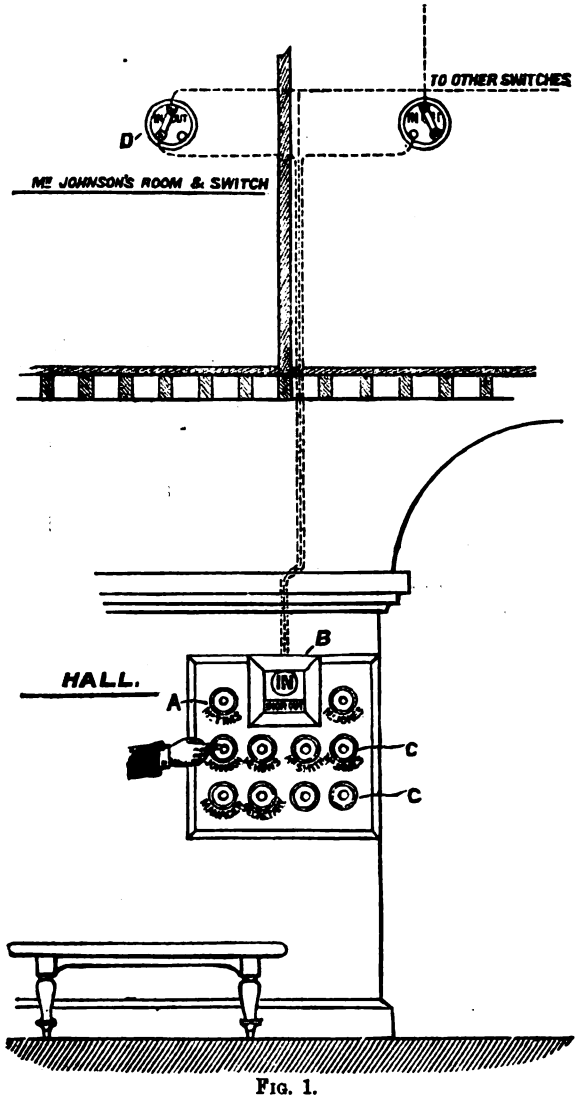


FIG. 1.

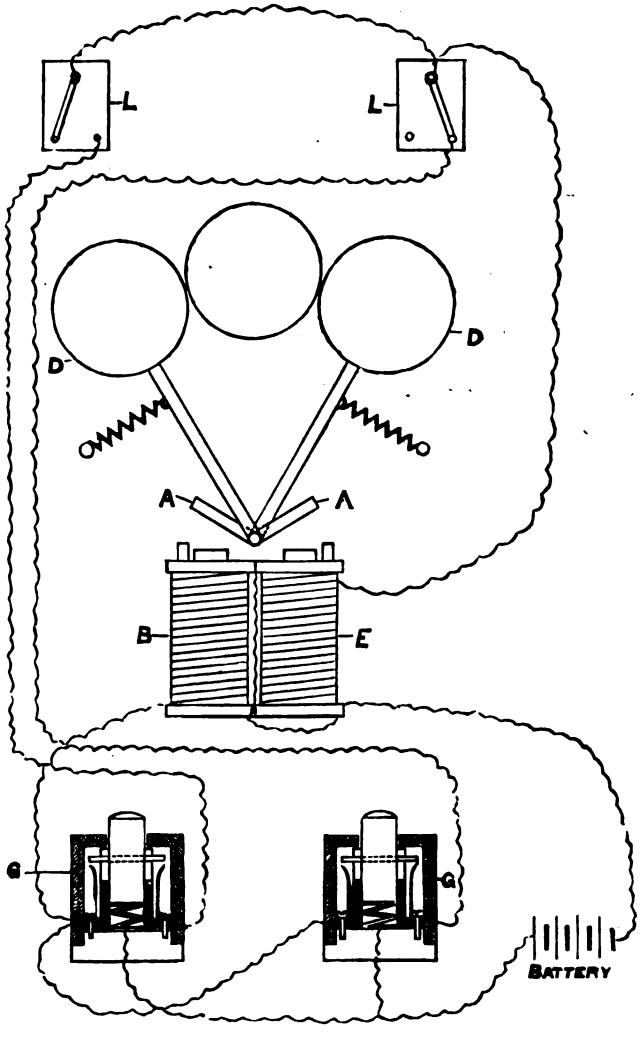


FIG. 2.

The accompanying illustrations show a new application of electricity to domestic purposes lately designed and patented by Mr. N. G. Thompson, of Messrs. Thompson, Dowsing, and Rew, 4, Queen Victoria-street. The purposes for which it is applicable are entirely distinct from, and have nothing in common with, that of the ordinary bell indicator, its object being to inform any visitor or person who may enter the hall of a building if the friend or the man of business called on is *in* or *out*, without wasting time and strength in mounting the stairs.

It is well known that in most public buildings, and almost all flats, metal indicators set by hand are employed for the above purpose, and the great advantage of this new form of electrical indi-

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cator over the old mechanical system is that the indications cannot be tampered with by mischievous persons entering the hall, and also that the determination of the indicator is regulated entirely from the inmate's room. This latter advantage is well illustrated in cases of families living in flats, where it may be desired to indicate "out" at certain periods of the day without the trouble of having to send down stairs to do so.

The general arrangement of the system is shown in Fig. 1. A board, A, is placed in the hall in any convenient place, and on this is fixed a single indicator, B, and any number of pushes, CC, as shown. Each push is in electrical communication with the indicator, and also with one of a number of switches placed in the different rooms. Each push, then, has communication with one particular switch and none other, but all the pushes are connected with the indicator.

Assume, then, that Mr. Johnson has a switch in his room, as shown at D; by altering this switch to either one of two positions anybody pressing his push on the board below will observe at the indicator either one of two indications, according as Mr. Johnson has set his switch above; and the same will apply to all the other pushes. The indicator only indicates during the time of pressing the push, and shows a blank when this is released, so that no replacement of any kind is required below. The system is worked by means of ordinary Leclanché cells, it is excessively simple, and almost impossible to get out of order.

The construction of the indicator is shown in Fig. 2. The two magnets B E, with their corresponding armatures A A, and indicating discs D D, may be excited by either one single or two separate circuits. In the first case the current is sent through both magnets when both discs are required to rise, and through only one magnet when only one disc is required to rise. As one disc obscures the other it is evident that when the back disc rises only, a different indication will be shown to that when both discs rise. The question whether only one magnet or both shall be excited is ruled by the position of the switches L L in the rooms above, the pushes G G only acting as contact makers and breakers. In the second case where separate circuits are employed to each magnet only one disc rises at a time.

Another arrangement is to place one magnet on a separate and independent circuit worked by a single cell, the switches and pushes having the same functions as before. Mr. Thompson has also provisionally patented another form of indicator, the position of whose discs is not only determined by the switch above, but is also worked by the action of setting it over. The indications in this case always show either "in" or "out," and require no manipulation on the caller's part.

The interesting feature of this form is that the disc in performing its action breaks circuit, but makes contact for another circuit on the open side of the switch, which, when again placed over, repeats the action, and thus the battery is only momentarily on whilst the disc is falling over.

We have examined the form of indicator as set up at Mansion House-buildings, and it seems to us that the arrangement is one that will prove of great convenience in the majority of business houses.

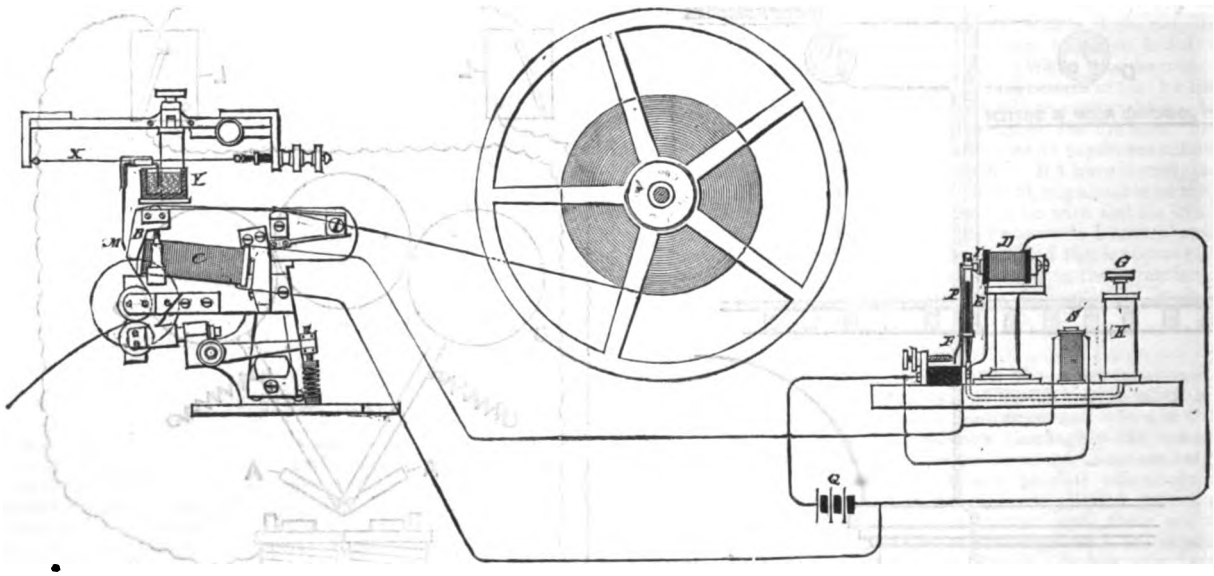
THE CUTTRISS PATENT SIPHON VIBRATOR FOR CABLES.

The use of static electricity to vibrate the siphon, with the object of preventing friction at the marking point of Sir William Thomson's siphon recorder, has always been the one defect in this otherwise most perfect and beautiful instrument; for, as is well known, in damp weather static electricity is difficult to produce and well nigh impossible to control. In such weather the operator working an electrified ink recorder must generally be confined in a room with all windows and doors closed, and frequently lamps or some sources of artificial heat are placed around the instrument to keep it dry, in order to prevent the escape of electricity. It is necessary to take this precaution even in the hot and sultry weather of August.

The paper on which the record is to be traced must also be kept in various places from cellar to garret, and oftentimes other means are resorted to so that it may be of different grades of moisture; for if the paper be too dry the electrified siphon oscillates wildly across it in its endeavour to discharge itself, while if it be too damp the siphon is discharged too effectually and the record fails.

The present invention, recently patented, obviates all this trouble by the use of magnetism, and the instrument works just as perfectly, be the weather damp or dry. By reference to the accompanying illustration it will be observed that the siphon M is slightly thicker toward the point; this is caused by a small particle of iron wire, No. 30 or 32, about $\frac{1}{16}$ or $\frac{3}{32}$ of an inch in length, fastened to it by a little shellac varnish. The magnetic recording table B, opposite the point of the siphon, over which the paper slip passes, is made partly of iron, and to the back of it is attached the electromagnet C. The addition of this magnetic table is all the alteration necessary to any recorder in order to enable the present system to be used.

The principal part of the invention is the adjustable vibrator at the right of the illustration. The glass tube E and armature I,



Cuttriss's Patent Siphon Vibrator.

which are supported by the steel rod P, are vibrated by an electromagnet D. Continuous vibration is maintained by means of the battery Q and the contact points F. The upright mercury reservoir K has a regulating screw, G, the lower end of which is made to act as a plunger; a small india rubber tube connects the mercury reservoir with the glass tube E, so that by raising or depressing the plunger the mercury can be forced and maintained at any required height in the glass tube, and by this means its rate of vibration can be changed as may be required. Whenever a new siphon is attached to the instrument it may become necessary to alter the rate of the vibration owing to the fact that even so delicate a tube as one of these siphons (which is about ·01 of an inch in outside diameter), has its own natural rate of vibration, depending upon its weight, thickness, and the amount of strain upon the wire supporting it; therefore, the impulses it receives from the magnetic table must be synchronous with its natural rate of vibration, otherwise the record will fail. When a siphon is attached to the strained wire X, and it has become filled with ink from the ink reservoir Y, the plunger is manipulated until the siphon attains its maximum arc of vibration. A perfectly steady dotted line is then obtained and will continue without any other regulation so long as it remains filled with ink.

Generally a permanent steel magnet is arranged so that one pole is opposite the magnetic table, and at about a distance of half an

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inch from the siphon. This concentrates the lines of magnetic force in such a way that all the battery required is three gravity cells of low resistance. The contact points F have a spark-arresting coil, S, connected to them, so that in practice they have given no trouble, and during the two months that the instrument has been in use on the Commercial Cable Company's recorders in this city not a single failure has occurred in their action.

It was feared that the siphon might show a tendency to be attracted laterally towards the centre of the magnetic table ; but such is not found to be the case. No lateral movement can be detected, whatever be the position of the siphon when the battery circuit is broken, and the table demagnetised ; nor is there the slightest retardation experienced to its lateral movements across the magnetic field. In fact the success of the invention is so pronounced that the company is about to adopt it on all its cables as soon as instruments can be made. There is a wide field for the introduction of this system, as it can be applied to any delicate mechanism of whose movements it is desirable to take a permanent record.—*Electrical World.*

ON A NEW LAMP AND LANTERN FOR LECTURE ILLUSTRATION.

The combination of lamp and lantern described below and illustrated in Figs. 1 and 2 was designed for the purpose of obviating some of the inconveniences which are experienced in the use of most instruments of this kind. As the arrangement possesses some points of novelty, the description may be of interest to those who are in the habit of using such apparatus.

An elevation of the lamp, which is of the form patented by Prof. A. Gray and Mr. Thomas Gray some years ago, is shown in Fig. 1, and another in Fig. 2, which also illustrates the manner in which it is combined with the lantern. A small Gramme motor, M, is fixed to a cast-iron sole plate, p, which forms the roof of the lantern. On the spindle of this motor three pulleys p_1, p_2, p_3, and a drum D are fixed. Fine cords c_1, c_2, c_3 are fixed to and passed several times round the pulleys p_1, p_2, p_3, then over the small wheels at the top of the frame, and attached to the ends of the carbon holders h_1, h_2, h_3. The cords are passed round the pulleys in such a way that the revolution of the motor moves the carbons in opposite directions, and the sizes of the pulleys are arranged to give as nearly as possible a constant position to the arc. The upper carbon is guided in its up and down motion by means of a hole in the cross bar b, large enough to allow it to pass freely, and by the cross bar b_1, fixed to the top of the holder h, and sliding freely between the two tubes t, t. The lower carbon holder is guided by means of insulating washers, fixed on the ends of the rods h_2 h_3, and sliding freely between the tubes t, t, and by two similar washers fixed in the lower ends of these tubes. It will be observed that the guiding points for the two carbon slides are in all cases far apart, and thus admit of very loose and frictionless fitting, while at the same time they insure that the carbons will be maintained accurately opposite each other, and at a constant distance from the lenses of the lantern. The upper carbon clamp consists of a thick disc of brass, d, fitting into a slit in the holder, and pierced with a hole the diameter of which is a little greater than that of the carbon. The carbon is passed through the hole in this disc, which is then drawn to one side by means of the nut n, thus pressing the carbon against one side of the holder and keeping it fair. The upper holder tube is partly filled with lead, and forms the driving power which causes the carbons to feed forward as they are consumed ; but it is left hollow for such a depth as to admit a length of carbon sufficient to form a lower carbon after the normal length of carbon has been consumed. The lower carbon holder consists of a spring tube, h, slightly conical at the upper end, which when the carbon is inserted fits tightly into a conical hole in the block B. A very small length of carbon is sufficient for the holder, and hence the waste of carbon is reduced to a minimum. It is sometimes desirable to place one carbon in front of the other slightly in order to obtain the maximum amount of light, and in order that this may be readily done, or undone, as required, the holder block B is made in two parts, which are a little excentric relatively to each other, and hence by simply turning the inner part through half a turn the carbon is moved backward or forward through a sufficient distance to give the end of the positive carbon a slope to the front. The change from the centre to the excentric position, or *vice versâ*, can thus be made almost instantly, and from the outside of the lantern. This excentric tube and the electrical connections to the different parts of the motor and the carbon holders can be readily imagined from the following description, and are for simplicity omitted in the drawing. Two terminal screws, one of them well insulated, are fixed to the sole plate p of the lamp. The uninsulated terminal is connected by means of a flexible electrode, and the contacts of the bars b and b_1 with the upper carbon ; the lower carbon holder is connected by a flexible electrode with the opposite ends of the high and the low resistance coils of the magnets of the motor ; the low resistance circuit includes the armature through which it is completed by means of flexible soft brushes arranged to bear lightly, but securely, on the commutator ; the other ends of the motor coils are connected to the insulated binding screw on the sole plate.

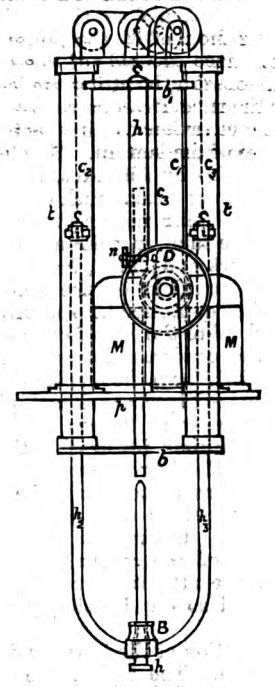

FIG. 1.—Gray's Lamp.

The electric circuit can thus be completed by connecting the poles of a generator, which may be either a dynamo or a secondary or primary battery to the two terminals on the sole plate. When the circuit is completed the powerful current which immediately begins to flow through the low resistance coils of the motor causes the armature to turn and strike the arc, which it maintains at such a length that the power of the motor is just sufficient to balance the

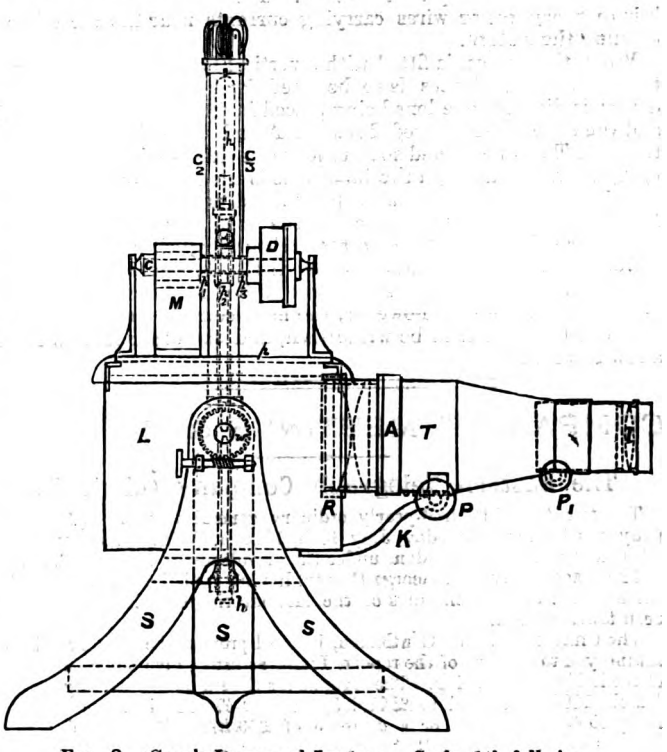

FIG. 2.—Gray's Lamp and Lantern. Scale, ⅛th full size.

gravitation power of the upper carbon holder. The feed is perfectly continuous, because as the carbons burn and tend to lengthen the arc the current decreases and gravity predominates, causing the carbons to feed together. The magnets of the motor are in the above description supposed to be differentially wound ; for a single lamp this is unnecessary, but in general more convenient, as the

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instrument may then be included in an ordinary lighting circuit along with other lamps.

The drum D, shown on the spindle of the motor, is fitted with perforated partitions and partially fitted with mercury. Its function is to steady the feed of the carbons and prevent oscillations of the length of the arc.

The lantern L consists of a round or a D shaped vertical cylinder of sheet iron or brass blackened on the inside. On the top of the cylinder, and forming the roof of the lantern, is placed the base plate *p* of the lamp. Into one side of the cylinder—the flat side when it is D shaped—a collar, R, fitting the lens tube T, is fixed, and through this collar the tube T can be passed from the outside, thus avoiding the usual inconvenience of having to insert the condenser lenses from the inside of the lantern. The lens tube is supported by the collar R, and also by a bracket, K, on the end of which is fixed a pinion, P, working into a rack on the tube T, for the purpose of moving the condenser nearer to or further from the arc. In the outer end of the tube an achromatic lens, *l*, is fixed, which can be focussed by a rack and pinion, P_1, in the ordinary way. The whole is mounted on trunnions on the stand S, and the beam of light can be elevated or depressed at pleasure by means of a worm and toothed wheel, fixed to the end of one of the trunnions.

The insertion of the condenser lenses into the tube T, and the introduction of the whole from the outside of the lantern, together with the facilities provided by the rack and pinion P for changing the distance of the lenses from the arc are very convenient. For instance, in ordinary diagram illustration the magnification can be readily adjusted to suit the distance and the size of the screen, or, on the other hand, a parallel beam may be obtained for such purposes as spectrum illustration; or the image of the arc itself and the carbon points may be thrown on the screen to illustrate the mode of consumption of the carbons, the effect of placing impurities in the arc, the attraction and repulsion of currents and magnets on the arc, and so on, by simply turning the pinions P and P_1.

The peculiar construction of the lamp renders it very suitable for these latter experiments. The fact of the carbons being free to move apart renders it easy by simply introducing a fragment of a metal, or one of its salts, to obtain a long arc, and, besides, substances can be placed in the crater of the lower carbon in an instant. It is only necessary to run the carbons apart so as to break the arc, place the substance in position, and allow the carbons to feed together, when the arc will immediately be struck. The arc will, in consequence of the metallic vapour, be a considerable length, and thus well suited to show either the spectrum lines of the incandescent vapour or the action of a magnetic field in the arc. In a new instrument at present being made facilities will be given for bringing magnets or wires carrying currents near the arc without opening the lantern.

When the lantern is fitted with a vertical beam arrangement, and the same set of lenses is to be used for both purposes, the condenser is divided, one lens being placed in front of the slide box A, and the slide tube hinged between A and the other lens, so that the tube T can be turned so as to leave its axis vertical. The beam of light passing through the inner lens is then thrown up by reflection from a mirror or a large prism, and is again reflected to the horizontal after passing through the lens *l* by means of another mirror or prism. In this case the rack into which P works is fixed to the part of T, which passes through R. For experiments which require a vertical beam, a separate tube, fitted with lenses and reflectors complete, is, however, the most convenient arrangement. The one tube can then be withdrawn, and the other introduced in a few seconds.

COMPANIES' MEETINGS & REPORTS.

The Eastern Telegraph Company (Limited).

The twenty-eighth half-yearly ordinary general meeting of this Company was held on Thursday, July 15th, 1886, at Winchester House, No. 50, Old Broad-street, London, under the presidency of John Pender, Esq.

The SECRETARY (Mr. George Draper) having read the notice convening the meeting, and the minutes of the last meeting and the report having been taken as read,

The CHAIRMAN said: Gentlemen, before I propose the formal resolution asking you to approve of the report, I will, as usual, give some particulars of the half year's working. The revenue for the six months ending the 31st March, 1886, amounted to £341,405, against £371,682 in the corresponding period of last year, or a decrease of £30,277. You will observe on reference to the accounts that there is a decrease in the return from our investment in the South African Company of £1,950. Owing to diminished receipts the South African Company has been able to pay a dividend of only 6 per cent., as against 7 per cent. in the previous year. Our Indian traffic has been fairly maintained, but the traffic to countries beyond India has declined since December last. The chief cause of our decreased receipts arises from the absence in the past half year of political and other events which in 1885 augmented our Indian and Egyptian traffic to an exceptional extent. The total working expenses amounted to £92,244, against £91,599 in the corresponding period of 1885, being an increase of £645. But in this half year are included several items of an exceptional character, such as expenses of removing into new offices, £265; expenses relating to negotiations in France, Germany, and Egypt, £940; expenses *re* Government protection of submarine cables, £45; cost of transfer of Trieste-Corfu concession, £316, making a total of £1,566. There is also charged to revenue account an amount of £1,788, the cost of duplexing the Zante-Alexandria cable. If we exclude these exceptional items the total working expenses for this half year, as compared with the corresponding period of last year, would show a considerable decrease. The general expenses in London were £8,773, against £7,617 in the corresponding period of last year, being an increase of £1,156. The principal items of increase are—offices expenses, £229; rent and taxes, £725; and repairs and renewal of furniture, £237. This is mainly due to our having removed to larger and more commodious offices, which we found were absolutely necessary to carry on the business of this Company, grown, as it has, within the last few years. Salaries and wages, stationery and printing, and law charges, show decreases amounting in the aggregate to £176, and working expenses at stations amount to £64,439, against £65,582 in the corresponding period of last year, or a decrease of £2,143. With reference to the items shown separately on the revenue account, use of patents shows a decrease of £1,600. The amount written off for depreciation of cable stores this time is £4,200, against £2,795. We have carried £5,000 to maintenance ships reserve fund, against £6,000 for the corresponding period of 1885. Expenses attending repairs and renewals and laying of cables amount to £41,637, against £44,815 for the corresponding period of last year, or a decrease of £3,178. It will be seen on reference to Abstract C that full details of the work done by our ships are given. Numerous important repairs have been effected, and, in addition, the "Volta" steamship has laid two new 3-core cables across the Straits of Messina, the cost of which is taken from revenue. But a large part of this sum is due to the sudden breaking of both our Bombay cables in 800 fathoms during a cyclone. These are now repaired, of course, and are in working order. After charging all expenses, including income-tax, providing for interest on debentures, debenture stock, and preference shares, we are enabled to pay a dividend of 5 per cent. with a bonus of 1 per cent., or at the rate of 6 per cent. per annum, and to carry to general reserve fund £70,000, leaving a balance of £4,079 to be carried forward to next account. I think, gentlemen, you will agree with me that this, upon the whole, is a very satisfactory account to lay before you to-day. Now, gentlemen, we are making a new departure in regard to rates arising from the Conference which was held last year at Berlin. On all sides we hear—"Only reduce your rates, and you will have a largely increased revenue." We are very anxious to reduce the rates, but we think the risk ought not to be entirely with the Company, but should be shared by those who want reduced rates. Governments, even, are interfering in trying to get reduced rates. What we are now trying to establish, both in Australia and in other parts, is this: We say to them, if they will guarantee us such a rate of traffic or returns as we have been enjoying during the last three years, they may make the tariff pretty much what they please. In other words, we are endeavouring to establish a system which will be practically a guaranteed rate for the proprietors of these companies, and which at the same time would be an enormous advantage to the different Governments and the telegraping public of those Governments, because they would be able to reduce the rates to an extent which would be simply impossible for the Companies without this guarantee. These negotiations are going on at the present time with Australia, and although they are as yet looked upon with some little shyness, I think those who represent the colonies and who look carefully into the question, are satisfied that this must finally be a solution of the question of a reduction of rates, and when that occurs you will practically be enjoying as proprietors of this Company a guaranteed rate of interest upon your shares. Gentlemen, I refer to that matter because it is very much occupying the thoughts and the time of your Directors at the present moment, and I am hopeful that those negotiations will make such progress as by-and-bye will be very beneficial indeed to the Company. I see calculations made from time to time as to our property, but there is one thing you may be perfectly satisfied about, viz: that telegraphy must grow. Politics and commerce alike demand it. Those who talk of anything like a decline in telegraphy speak nonsense. Human nature is in accord and harmony with telegraphy, which will and must grow. As nations grow so also will telegraphy, and therefore I have no fear as to the calculations of those who talk about our going back, and that our stocks must be reduced in value. I have no sympathy with them at all, and depend upon it as long as telegraphy has the hold which it has at the present time upon the public generally there is no great fear of its declining, unless unnecessary and undue competition arises, and that is a question which we shall take as much care as we possibly can to avert.

Now, at the Berlin Conference—I think I mentioned this to you last year—an important question arose about Egypt. I went out to that country in the spring of this year, and saw the Egyptian Government on the subject, and I am pleased to say that what we supposed was going to result in a considerable annual payment from the Company to the Government was entirely set aside. We are therefore precisely in the same position to-day as we were in before we went to Berlin, and as we consider our position a very strong one, should the question again arise, if we have to give something we shall also get something in return. Depend upon it, your interests in that respect will be carefully guarded. I think these visits to different Governments and stations abroad are calculated to do good in many ways. All our stations are in the most perfect working order. Visits to them occasionally give encouragement to our young men, and I find when we compare our stations with those of other nations we as Englishmen have every reason to be proud.

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We received intelligence yesterday of a company with which we are in very close alliance, namely, the Direct African Telegraph Company. We received yesterday a congratulatory message from the governor of Sierra Leone. Probably within two or three weeks the whole line will be laid, and when completed, that system will become a feeder for our Eastern system from Lisbon. Therefore, as far as I can see, we are at the present moment in a very satisfactory position. Since I had the pleasure of addressing you last the Direct African concession has come before the Government. There were some remarks made on that occasion in the House of Commons by a gentleman who was interested in an opposition company to Australia. He admitted that if this West African concession were passed it would be the deathblow to his scheme. As that scheme was of a nature which I think was perfectly uncalled for and unnecessary in any sense, I am very glad to find that our concession was approved, and it ought to have been, because there is no bargain ever made with a Government which has been so straightforward, and so much in the interest of the public generally. I am pleased to say that the concession passed through the hands of three English Governments, and was checked in every possible way, and I am glad to find that the Secretaries of the Treasury of those respective Governments defended it in the House of Commons in a way which must have been very unsatisfactory to those who challenged it, but very satisfactory to those who were interested in it. Now, gentlemen, with these remarks, I beg to move :—

"*That the printed report and accounts of the Directors to 31st March, 1886, submitted to this meeting, be, and the same are hereby, received and adopted. That a dividend on the preference shares of the Company to 30th June, 1886, at the rate of 6 per cent. per annum be paid, less income-tax, and that in accordance with the Directors' recommendation a dividend be, and is now, declared of 2s. 6d. per share, with a bonus of 1s. per share, both free of income-tax, on the ordinary shares of the Company, making, with previous payments by way of dividend on account, a total payment of 6 per cent. on those shares for the year ended 31st March, 1886.*"

The VICE-CHAIRMAN (the Marquis of Tweeddale): I beg to second the resolution.

The CHAIRMAN: Now, gentlemen, if there is any shareholder in the room who desires to put any question to me, I shall be happy to answer him before putting the resolution. No one rising to address the meeting, he continued: Well, gentlemen, the resolution has been moved and seconded, and those in favour of it will please signify the same in the usual manner. To the contrary? Carried unanimously. That, gentlemen, closes the business of the meeting so far as the resolution is concerned. I might say that you will notice that we have met in a new hall to day. I hope you will all find it to be so much in the centre of the City that it will meet the requirements of the various companies who have found it hitherto rather onerous to carry their books and papers down to the Cannon-street Hotel.

Mr. JOHN NEWTON: Mr. Chairman, I have very much pleasure in moving a vote of thanks to you and your colleagues for the manner in which you have conducted the business of the Company during the past half-year and for some time past. I think that the manner in which Governments are dealing with the property of shareholders in telegraph companies is scarcely fair to telegraph shareholders, and I also think our Directors have protected our interests as much as possible under the circumstances. We are not fairly treated by the governing bodies of the country, seeing the immense value and importance that we have been to all business transactions and all social intercourse between nation and nation; and it is unfair that we should be so trammelled and hampered in our attempts to get a fair and proper remuneration for the capital invested in these companies [hear, hear]. I think the manner in which you have protected our property under the circumstances in which we are assailed deserves a hearty vote of thanks on this occasion, which I beg to move.

Mr. MUIR: I second that.

The SOLICITOR (Mr. Burt): Mr. Newton has moved that a vote of thanks be given to the Chairman and Directors for their conduct of the Company's business. Those in favour of that will please signify the same in the usual manner. To the contrary? Carried unanimously.

The CHAIRMAN: On behalf of my colleagues and myself I return you our best thanks. I may say that we take very great pride in the progress and prosperity of this Company. We have a great deal to contend against. As I have said to you, telegraphy is growing, but every one seems to think that it ought to be much cheaper than it is. While we are protecting your interests we are also most anxious to give such an impetus to telegraphy as we can by reducing the rates, but consistently with your interests. Depend upon it, we shall do all we can in the future to maintain the success of this Eastern system of telegraphy, and in a way which will be of benefit to the world and advantage to the shareholders, who have done so much. I beg to thank you. I may tell you that our offices are now in this building, and if there is any gentleman who wishes to look round them I think he would get some idea of the amount of work that is going on to keep this system in active operation. We shall be very pleased, on application to the Secretary, to show the offices to any gentlemen who wish to see them.

The proceedings then terminated.

Telegraph Construction and Maintenance Company (Limited).

In accordance with the resolution of the general meeting of 28th Feb., 1871, a half-yearly general meeting of this Company was held at 38, Old Broad-street, on the 20th inst., Sir Daniel Gooch, Bart., in the chair.

The MANAGER (Mr. Shuter) having read the notice convening the meeting,

The CHAIRMAN said: Gentlemen, at these meetings, as you are aware, we do not present any accounts or report to you, but simply give you shortly a statement of the work done during the past few months. I may tell you that during the half year we have laid a cable 398 miles in length between Penang and Singapore, replacing an old cable that was picked up. We have also laid 1,130 miles of cable along the West Coast of Africa. When completed, this cable will embrace a length of about 2,000 miles, and will connect the African settlements from Bathurst to the river Niger. We have manufactured during the year about 2,100 miles of cable. I may say that the prospects for the next half year are not so flourishing, but we must trust to fortune to get us more work. The only other point I need refer to is as to the question of electric lighting. That has been in operation for three months, but legal difficulties have been raised as to noise or annoyance, or whatever you may choose to call it, with some of the houses closely adjoining the works. These difficulties are still matter of litigation, and therefore I am not able to go into the subject. I must leave that to the next general meeting. I do not know that I have anything more to say, but I shall be glad to answer any question.

Mr. HOLDSWORTHY: You say there is litigation. Is the light still going on?

The CHAIRMAN: The lighting is still going on. We do not know what the result may be.

Mr. HOLDSWORTHY: No, I only asked for the fact. I should be sorry to ask any question as to the litigation.

The CHAIRMAN: As far as the light is concerned, it is a perfect light. The only question is, can we produce it without annoyance to our neighbours? Is there any other question, because we have no resolution to move at these meetings?

Mr. GIBSON proposed a vote of thanks to the Chairman and Directors, to whom, he said, the shareholders were very much obliged for their care and attention to the affairs of the Company.

The CHAIRMAN: We are very much indebted to you, and we hope that we may be as prosperous in the future as we have been in the past. We shall do our best, at any rate, to assure that. I now declare this meeting closed.

India Rubber, Gutta Percha, and Telegraph Works Co. (Limited).

A half-yearly general meeting of this Company was held at the Cannon-street Hotel on the 20th instant, "for the purpose of obtaining the sanction of the shareholders to the payment of an interim dividend of 5 per cent., or 10s. per share, free of income-tax." Mr. S. W. Silver presided.

The SECRETARY (Mr. W. J. Tyler) read the notice convening the meeting.

The CHAIRMAN: Gentlemen, the notice conveys the object of our meeting to-day. As our books are made up but once a year, we have no results to present to you. The general report I have to make to you is that business, considering the generally depressed state of trade, is fairly good. Our works are in excellent condition and order, both in England and France, and our steamers are fully occupied. Without detaining you further, few as these remarks are, I will move that this interim dividend of 5 per cent. be paid.

Mr. NEIL BANNATYNE seconded the motion.

The CHAIRMAN: It is payable to-morrow. He then put the motion in the usual way, and it was carried.

Mr. CATER gave notice that at the next general meeting of the Company he would bring forward for the consideration of the shareholders the question of the large amount which was set aside for the remuneration of the Directors. At the last general meeting the amount was £1,100 each, and that had been increased since then by the augmentation of the direction.

The CHAIRMAN: I think you are in error as to the increase. There has been no increase.

Mr. CATER said he was very glad to hear it. The next balance-sheet would show what the amount was.

Dr. D. H. SMALL moved a vote of thanks to the Chairman and Directors for the continued success which attended the Company. He had been to the works at Silvertown, and had been very much pleased at what he had seen. He believed that the cables turned out by the Company would be as good as those manufactured by any other company.

Mr. TREBLE seconded the motion, which was carried.

The CHAIRMAN: In the name of my brother Directors and myself I would thank Dr. Small for the observations he has made, and for the vote of thanks proposed. I assure you that the attention that has been paid hitherto to your affairs shall, if possible, be increased in future.

Mr. PAINE: Would the Chairman kindly tell us what amount of fees each Director receives per annum?

The CHAIRMAN: The minimum is £2,000, and the maximum £5,000.

Mr. PAINE: Is not that for the whole Board?

The CHAIRMAN: Yes. The business is now at an end, gentlemen.

Anglo-American Telegraph Company.

Report of the Directors, to be presented at the ordinary general half-yearly meeting of the proprietors, to be held at the Cannon-street Hotel, on Thursday, the 29th inst, at 2 o'clock p.m. :—

The total receipts from 1st January to the 30th June, 1886, including a balance of £4,096. 13s. 7d., brought forward from the last account, amount to £116,737. 11s. 9d. The traffic receipts show a decrease as compared with the corresponding period of last year of £22,321, consequent upon competition, a reduced tariff, and continued depression of

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trade between Europe and America. The total expenses of the half year, including repair of cables, &c., as shown by the revenue account, amount to £46,813. 12s. 7d. The Directors, under the powers conferred upon them by the Articles of Association, have, before declaring the net profits, set apart the sum of £50,000 to the renewal fund, leaving a balance of £19,923. 19s. 2d. One quarterly interim dividend of 5s. per cent. on the ordinary stock, and of 10s. per cent. on the preferred stock, was paid on the 1st May, 1886, absorbing £17,500. It is not proposed to declare any interim dividend for the past quarter, but to carry the balance of £2,423. 19s. 2d. forward to the next account. The Company's repairing steamship "Minia" has been engaged during the past half year in the repair of the Northern Placentia and Duxbury cables, and also of the Direct United States Cable Company's short section cable between Torbay and Rye-Beach. The whole of Company's cables and land lines are in good working order, with the exception of the Duxbury cable, which was again broken on the 2nd instant. In the month of May last, a Conference was summoned by the French Government and held at Paris, at which the principal European and American States were represented, for the purpose of reconsidering the clauses of the Convention of 1884, for the protection of submarine cables, which had been modified at the instance of the English Cable Companies by the Acts of Parliament passed in 1885. A committee was appointed by the Conference to examine the details of the modifications, and to hear the views of the Telegraph Companies on the subject. The delegates of the companies (including the Managing Director of this Company) attended the committee, and after much discussion the Conference adopted declarations which fairly satisfied the requirements of the Cable Companies. The reduction of tariff from 2s. to 1s. 8d. per word introduced by the Commercial Cable Company (Mackay-Bennett cables) on the 24th December, 1884, resulted in a large decrease in the gross revenue produced by Atlantic cable traffic. Nevertheless, it was determined by the associated Cable Companies to give the reduced tariff a fair trial, in order to avoid a war of rates, and to determine as early as possible whether the reduction would result in any remunerative increase of traffic. After more than a year's trial it was found that the very contrary was the case, and as the rival company resorted to means to obtain a greater share of the traffic than the possession of two cables fairly entitled them to, the Directors of the associated companies came to the conclusion, that it was necessary in the interests of their proprietors to adopt a low rate. Accordingly on the 5th May, 1886, the rate was reduced by the associated Cable Companies to sixpence per word, and by special arrangement with the Western Union Telegraph Company of America this tariff was made to extend to all the principal cities and towns in the United States and Canada. For press news a special rate of threepence per word between London and New York was also adopted. On the same date the tariff of the Mackay-Bennett cables was reduced to one shilling per word. The effect of this important reduction of rates by the associated companies has been a very considerable augmentation of the traffic, much larger indeed than was anticipated as a first result, amounting to over 110 per cent., and although the total receipts have greatly decreased, the Company is earning sufficient to pay its working expenses, and to place such a sum to the credit of the renewal fund as with the accruing interest will soon bring that fund up to £1,000,000, the limit fixed by the proprietors at the last half-yearly meeting. The unexpected increase in the volume of traffic immediately upon the introduction of the sixpenny tariff has induced the Directors to consider the expediency of adopting permanently a system of low rates. The associated companies possess between them no less than eight cables across the Atlantic, having a carrying capacity which for practical purposes is unlimited. With such an extensive system, it is obviously their interest to encourage a very large traffic at low rates, and by so doing prevent a further multiplication of unnecessary cables. By the recent reduction of rates cable customers and the public have the opportunity of answering the question upon which the future rate between Europe and America will have to be decided, namely, whether there is a sufficient inherent development in the cable traffic to and from America, to warrant a low charge being permanently established. If there be such development, and the public respond to the desire of the associated companies to continue working at low rates, it will be to the interest of the companies to do so, as they only desire to earn a reasonable return upon the capital invested, and prevent further wasteful competition. The Directors would remind the proprietors that the Company has now been in existence for over twenty years, and that although high rates were in the first years of the undertaking an absolute necessity, and were not at that time objected to by any important class of the community, they have since been found, whenever adopted, to produce continuous competition, useless multiplication of cables, and loss of money to all the companies interested. The Directors believe that sooner or later a low tariff will be a necessity, and that by "taking time by the forelock" and making an earnest effort now to establish it, they will secure the cordial approval and co-operation of their customers and the public, without which so important a step could never be successfully adopted.

CRICKET.

Messrs. Willans and Robinson *v.* Messrs. Woodhouse and Rawson.

A cricket match between the employés of the above firms was played on July 17th, on the village green at Thames Ditton. The party from the works at Hammersmith arrived at Thames Ditton at 10:30, when they were conducted over the Ferry Works by J. C. Peache, Esq., the manager, and had an excellent opportunity of inspecting the many interesting types of engines in course of construction for Her Majesty's Government and others. Amongst the various improvements we noticed the plan of casting the bed-plate of engine and dynamo in one solid piece, thereby securing great strength with considerable reduction of weight. About 11:30 an adjournment was made to the green, where, in spite of heavy rain, a start was made at 12:45. The electricians proved rather too strong for the engineers, who narrowly escaped being beaten in a single innings. The first three wickets of the visitors realised the useful amount of 130 runs, after which the remainder only added 36. At 3:0 an adjournment was made to the Red Lion for lunch, where the visitors were entertained by their opponents, and sat down to an excellent repast. Play was continued till 7 o'clock, with the following result. We must not omit to mention the excellent wicket-keeping of the local team and the free hitting of Thomas, Ward, and Rawson. A fine afternoon completed a most enjoyable day for the visitors, who have to thank their courteous opponents for their thoughtful hospitality. Score :—

Messrs. Woodhouse and Rawson.—B Thomas, st Deane, b. Sands, 20; C. R. Chambers, run out, 13; H. W. Ward, run out, 49; W. S. Rawson, b. Deane, 47; W. Long, st. Reeves, b. Bounds, 0; J. Sinclair, b. Bounds, 0; M. S. Chambers, run out, 16; J. A. R. Milton, c. and b. Deane, 0; L. Parsons, st. Reeves, b. Thistlewaite, 0; R. Price, st. Reeves, b. Thistlewaite, 5; A. E. Ruddock, not out, 1; extras, 15; total, 166.

Messrs. Willans and Robinson, *1st innings.*—W. Deane, c. Rawson, b. Thomas, 7; S. Hiscocks, b. Rawson, 0; Thistlewaite, b. Rawson, 5; A. Sands, b. Rawson, 12; H. Reeves, b. Rawson, 0; G. Reeves, b. Rawson, 0; J. Miller, c. Sinclair, b. Thomas, 3; L. Bounds, not out, 6; W. Adams, b. Rawson, 7; E. Kedge, b. Thomas, 4; W. Rodwell, c. Renddock, b. Rawson, 2; extras, 3; total, 49. *2nd innings.*—W. Deane, not out, 24; H. Reeves, run out, 2; G. Reeves, st. Long, b. Ward, 0; J. Miller, not out, 6; L. Bounds, c. and b. Sinclair, 4; E. Kedge, st. Long, b. Ward, 0; W. Rodwell, c. Sinclair, b. Ward, 4; total, 40.

BUSINESS NOTICE.—Messrs. Swete and Main, Electrical Engineers, have removed from Battersea to 11, Queen Victoria-street, E.C.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. July 21.		Business Done Week Ending July 21. Highest.	Lowest.
Anglo-American	32¾,	33¼	32	—
Do. Preferred	53¾,	54¼	54	53
Do. Deferred	10½,	11	10⅞	10½
Brazilian Submarine	10⅜,	10⅝	11	10⅜
Cuba	10½,	11	10⅞	—
Do. Preference	18½,	19½	19	—
Direct Spanish	1½,	1⅝	—	—
Do. Preference	8½,	9	9⅛	9
Direct United States Cable	9,	9¼	9⅛	9 1-16
Eastern Telegraph	11,	11¼	11⅛	10 15-16
Do. 6 per Cent. Preference	14¼,	14½	14½	—
Do. 5 per Cent. Debentures, 1899	106,	109	—	—
Eastern Extension	12¼,	12⅜	12½	12¼
German Union	9¼,	9½	9⅝	9 9-16
Globe Telegraph and Trust	6 9-16,	6 11-16	6⅝	6⅝
Do. Preference	13½,	13¾	13⅜	13 5-16
Great Northern	12,	12½	12¼	12¼
Indo-European	34,	35	—	—
Reuter's	6,	6½	6½	—
Submarine	200,	210	—	—
West India and Panama	⅜,	⅝	⅜	—
Do. 1st Preference	8⅞,	9	—	—
Western Brazilian	7,	7¼	7 3-16	—
Western Union 7 per Cent. 1st Mortgage	118,	122	—	—
Do. 6 per Cent. Sterling Bonds	103,	107	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	13-16	15-16	—	—
Oriental	3-16	5-16	—	—
United Telephone	13⅛,	13⅜	13⅜	13⅛

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	2⅜,	2⅝	—	—
Do. (fully paid)	4,	4½	4	—
Swan	1⅜,	1⅝	1⅜	—
Maxim-Weston	3-16	5-16	¼	—

MISCELLANEOUS.

Telegraph Construction	39½	39¾	40¼	39½
India Rubber, Gutta Percha, and Telegraph Works	23	24	23⅝	23⅜

TRAFFIC RECEIPTS FOR JUNE, 1886.

Companies.	June, 1886.	June, 1885.	Increase.	Decrease.
Cuba Submarine	2,775	3,032	—	257
Direct Spanish Telegraph	1,513	1,343	170	—
Eastern Extension	38,894	37,846	1,048	—
Eastern Telegraph	45,100	41,514	3,586	—
Great Northern	23,600	—	—	—

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NOTES.

JAPAN.—A factory for the manufacture of telegraph wires and appliances is to be established at Tokio, Japan.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 23rd inst. amounted to £2,688.

PRESIDENT GREVY.—The Elysée and Mont-sous-Vaudrey are to be telephonically connected during the stay of the President of the Republic in Jura.

Mr. C. H. B. PATEY, C.B.—The Queen has been pleased to approve the appointment of Mr. C. H. B. Patey, Secretary Postal Telegraphs, to the Civil Division of the Order of the Bath.

ELECTRIC LIGHTING BY A GAS COMPANY.—The directors of the Waltham, Mass., Gas Light Company have determined to lay down an electric lighting plant for central distribution at a cost of $20,000.

PERSONAL.—Mr. Ernest Danvers has resigned his position of Inspector-General of Columbian Telegraphs, on account of the bad financial state of the country, and has removed to Caracas, Venezuela, South America.

SHEFFIELD *v.* BIRMINGHAM TELEGRAPHISTS.—The annual cricket match of these clubs was played on the ground of Messrs. Bass and Co., Burton-on-Trent, last Saturday. The result was in favour of the Sheffield team.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 23rd inst. were £2,118, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

THE TELEPHONE IN SCOTLAND.—The National Telephone Company have decided to immediately commence the laying of several telephone lines between Dundee and Glasgow, with branch lines to Edinburgh and other towns in that part of Scotland.

GERMAN PRESS RATES.—We hear that the the new rules regulating the tariff for press messages in Germany are causing much dissatisfaction. The rules are in many cases not a little arbitrary, and their effect is to considerably increase the cost of the service.

RYDE PIER ELECTRIC RAILWAY.—The directors of the Electric Railway Company of Ryde have issued their report for the last six months. The working of the railway has given great satisfaction, and the financial result exceeds the anticipations of the promoters.

TEMPORARY ELECTRIC LIGHTING.—Mr. F. Geere Howard has carried out a large number of temporary installations this season by means of the Holmes-Bourke primary batteries, the number of lamps used varying from thirty to eighty, of twenty candle-power each.

REMOVING OVERHEAD WIRES.—At Evansville, Indiana, the local telephone company having failed to comply with an order of the municipality to remove their overhead wires by a given date, the whole of the wires were cut and the poles were removed by the police force.

IMPORTANT TO ELECTRICIANS.—The subject for the next international competition for the King of the Belgians' prize of 5,000 dollars is "The Progress of Electricity, applied to motive power and illumination; its application and economical advantages." The essays have to be written in French.

EASTERN TELEGRAPH COMPANY.—This company notifies that the coupons on their Five per Cent. Debentures, due on 1st August proximo, will be paid after that date at the banking house of Messrs. Glyn, Mills, Currie and Co., 67, Lombard-street, E.C. Coupons should be left three clear days for examination.

LEICESTER EXHIBITION.—On Thursday last the models and certificates awarded to the successful exhibitors at the Leicester Exhibition, were presented at the Royal Institution. Messrs. Woodhouse and Rawson obtained a medal for their electrical exhibit, and a certificate for their Cunynghame, Woodhouse, and Rawson automatic cutouts.

MEXICAN TELEGRAPH STATISTICS.—The following particulars of the length of telegraph lines in the Republic are taken from a paper published in the capital:—Federal Government lines, 10,937 meters; State lines, 1,653 meters; railway line, 4,431 meters; private companies, 3,301 meters; and submarine cable, 703 meters.

THE FALLS OF CLYDE.—There is, it is said, a movement on foot just now for utilising the celebrated Falls of Clyde for generating electricity. Turbines for working the dynamos are to be fitted up at Stonehouse, whence the electric current will be transmitted by cables to the town of Lanark, where it will be used for lighting and other purposes.

REDUCTION OF GERMAN TARIFF.—The Director-General of Posts and Telegraphs in Germany has recently announced that the tariff for messages from Germany to the principal towns of the United States *viâ* Emden will be reduced from 1m. 65 to 65 pfennigs per word. A similar reduction will be made in the case of messages to Mexico and South America.

SCIENCE IN THE NEW PARLIAMENT.—Sir John Lubbock, Sir Henry Roscoe, and Sir Lyon Playfair appear to be the chief representatives of physical science in the Parliament just elected. Sir U. Kay-Shuttleworth, Mr. Nevil Story-Maskelyne, and Dr. Farquharson, who are known as writers on scientific subjects, may also be included in the number.

ELECTRICITY AT THE HELM.—The well-known French firm, Breguet, are at present engaged on some experiments which have for their object the applying of electricity to the working of the helms of ships. If the results are satisfactory, we may expect to hear shortly that four of the new packets of the General Transatlantic Company are steered by means of electricity.

WEST AFRICAN CABLES.—We are informed that the Silvertown Company's ships, the "Silvertown" and "Dacia," have successfully landed the shore ends for the Grand Bassam-Accra section for the West African Telegraph Company. As this work was finished on the 12th inst. we may expect from day to day to hear of the completion of the above-named section.

UNIVERSITY DEGREES.—In the recent examination at the University of London in electricity the following gentlemen received the degree of D.Sc.:—(*a*) Treated experimentally, Henry Stroud, St. John's College, Cambridge; (*b*) treated mathematically, John Thomas Riley, Mason College, Birmingham; (*c*) treated experimentally and mathematically, Robert Mullineux Walmsley, Technical College, Finsbury.

ALWAYS GRUMBLING.—The telephone is supposed to save the valuable time of business men; but when London subscribers have to stand for ten or fifteen minutes with the receiver up to their ear, waiting to be "put on," this can scarcely be called a saving of time. The fact is, that more trunk lines are required, considering the large and increasing number of subscribers in the London district.

PARIS GAS SHAREHOLDERS.—Considerable excitement has prevailed this week amongst the holders of gas stock and shares in Paris, owing to the uninterrupted success of the

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electric light installations that have recently been put up in the principal places of amusement and elsewhere. As one of the results of the scare, a marked depreciation in the value of gas shares in the French capital has been noticeable.

NARROW ESCAPE.—The Archduchess Frederick and her two little daughters had a very narrow escape from death by lightning last week. During a violent storm, when they were in one of the drawing rooms of the Palace at Pressburg, a powerful current of electricity struck the building, and, entering the room where the Princesses were sitting, knocked down a part of the wall only a few feet distant from the chairs they were occupying.

THE LATE MR. FAWCETT.—In memory of the late Professor Henry Fawcett a drinking fountain, subscribed for by women grateful to him for his work on their behalf, was formally unveiled in the Thames Embankment Gardens on Tuesday afternoon. The memorial is placed opposite Cleopatra's needle. Louisa Lady Goldsmid performed the ceremony, and the subsequent speakers were Lady John Manners and Mrs. Garrett Anderson.

THE LEEDS MUSICAL FESTIVAL AND THE ELECTRIC LIGHT. At a meeting of the Leeds Musical Festival Committee, held on Tuesday afternoon at the Town Hall, a resolution was unanimously passed in favour of employing the incandescent electric light at the forthcoming festival. A sub-committee was appointed to bring the matter before the Electric Lighting Committee of the Town Council, who it is confidently anticipated will give effect to the resolution.

METEOROLOGICAL OBSERVATIONS. — The *Centralblatt für Electrotechnik* says that the Austrian Society of Meteorology is planning an undertaking which promises to be of great service to meteorology and the kindred sciences. This is the erection of an observatory on the summit of the Tomblick in the Tanern, at an elevation of 3,100m. above sea-level. It will be the highest observatory in Europe, and is to be provided with the best instruments and registering apparatus.

THE PROPOSED CABLE VIÂ THE ANTILLES.—With reference to this cable, which formed the subject of our leading article last week, we learn that the national sentiment is to be consulted to a greater extent even than we imagined. The conditions of the concession stipulate that the cable is to be manufactured in France, shipped and laid by a French vessel, and worked by French hands. We would also suggest that none but French capital be embarked in the venture.

THE TELEPHONE IN AUSTRIA.—The telephone between Vienna and Brünn, a distance of one hundred miles, commenced working early this week, and is a complete success. The system employed is that of Ryssellberghe, which allows of the use of ordinary telegraph wire. Preparations are already being made for the establishment of regular telephonic communication between Vienna and Pesth, a distance between two and three times as great as between Vienna and Brünn.

TELEGRAPH PATENTS IN MEXICO.—A patent has been granted by President Diaz, dated June 12th, to Señor Don Francisco Javier Estrada for a system of telegraphic communication with railway trains in motion, the patent to extend for a period of ten years. "Is it possible," asks the *Two Republics*, "that Edison's latest telegraphic invention should have been duplicated in Mexico at the same time that some American inventors claim to have anticipated him?"

STORM WARNINGS.—M. Hervé Mangon, member of the Institut and president of the Congrés Officiel de la Meteorologie Française, has expressed a wish that the transatlantic cable companies should accord the benefit of a special tariff to the meteorological offices of Europe and America for the transmission of storm warnings, the important service of which to the shipping interest of the world, thanks to the efforts of General Hagen and the *New York Herald*, has been so much appreciated during the last ten years.

A NEW CONSTANT CELL.—Mr. H. P. Laurie has devised a cell which he claims to be practically constant. The negative plate consists of platinum, and the positive of cadmium. A solution of cadmium iodide containing free iodine is employed. The electromotive force of the cell remains constant at 1·076. There is, however, one small feature yet to be mentioned which is necessary to ensure the constancy of the cell, and some people would perhaps consider this feature as rather a disadvantage than otherwise. The cadmium plate must be rotated by clockwork, at a speed of from two to three revolutions per second.

M. BOISSELOT'S TELEPHONE.—This instrument, which was exhibited at the recent meeting of the Societé Internationale des Electriciens, is a modified form of the Bell, and is intended for use as a magneto transmitter as well as a receiver. Its peculiarity consists in the fact that the coils are wound upon soft iron cores, attached to the centre of an iron diaphragm. The iron cores are magnetised by a powerful horseshoe pattern steel magnet, which is fixed in such a way that it does not interfere with the movement of the diaphragm. M. Boisselot claims that this instrument is as good a receiver, and far better as a magneto transmitter, than anything previously devised.

WATER MAINS STRUCK BY LIGHTING.—Instances have more than once been recorded where water mains, being struck by lightning, have burst. It is scarcely probable that this is a direct result of the electric action; more probably the effect is due to a certain amount of steam being suddenly generated. A case has just been reported from Halifax, N.S., of a somewhat different character. A fire hydrant was struck by lightning, and notwithstanding the apparently easy passage to earth afforded by its connection with the main, the street pavement was torn up in a direct line for the distance of two blocks of houses. The tract thus opened seems to have been of considerable depth, for we are told that "large rocks were thrown to the surface."

MORE LAW.—We are at liberty to state that an action has been commenced by the Edison and Swan Company against the Jablochkoff Electric Lighting Company and Mr. Holland, of the Albert Palace, for selling and using the Victoria incandescent lamps, manufactured by the Anglo-American Brush Electric Light Corporation, and that steps are being taken to enable the Anglo-American Brush Electric Light Corporation to defend the action as third parties, and that the Corporation are giving full indemnities to all their customers. Also that the Anglo-American Brush Electric Light Corporation have commenced a suit against the Edison and Swan Company for injunction and damages for infringement of the Lane-Fox patents for incandescent lamps.

A FLOATING EXHIBITION.—A committee has been formed in Paris, under the patronage of the Syndicate de l'Industrie et du Batiment du Department de la Seine, and under the direction of M. de Berny, to organise a floating exhibition to go to different parts of the world, showing the products of the various industries of France. A vessel of 3,900 tons, named "La Sarthe," has been placed by the Minister of Marine at the disposal of the committee, which is forthwith to be fitted up in a manner suitable to carry out this novel experiment in the way of advertising. The vessel, which is to be lighted by electricity, will depart from Havre towards the end of the year

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on its first journey, and will call at the principal towns on the coast of Central and South America.

THE TELEPHONE IN MEXICO.—According to advices from the city of Mexico there appears to be little field for the telephone in the province of Lucatan, whatever inducements there may be in other parts of the Republic. When the telephone was first inaugurated at Merida the enterprise had over one hundred subscribers. At present, while the line has been extended to Progresso, the patronage is much reduced, the list only comprising 78 subscribers, of whom sixty-four are in Merida and fourteen in Progresso. The falling off of subscribers is attributed to the unsatisfactory state of business. Several large mercantile failures have occurred of late, which are attributed to the lack of banking facilities rather than to the inherent weakness of the firms in question.

WHAT IS ELECTRICITY?—The above question is propounded by Prof. Le Corguille as the heading of the first chapter in a series of elementary lessons which he is writing for the *Moniteur Industrielle*. After having our expectations aroused in this way, it is not a little disappointing to find that the learned Professor is only about to exhibit those interesting but decidedly mouldy relics the one-fluid and the two-fluid theories. Upon this side of the Channel, at least, it is tolerably well understood that so far as they could be supposed to afford any answer to the Professor's query, the fluids (one and two) have long since departed this life; and have been afforded honourable burial along with Caloric and Phlogiston, and Newton's Luminous Corpuscles, *et hoc genus omne*.

TELEPHONE EXTENSION.—Mr. Graham, the superintendent of the South England Telephone Company, attended the last meeting of the Irthlingborough Highway Board, and asked permission to erect poles west of the town of Wellingborough through the villages of Doddington, Earls Barton, and along the highway into the parish of Billing. He said it was the intention of the company to connect Wellingborough with Northampton, and then further to extend the poles to other centres of the shoe trade, such as Kettering, Rushden, and Higham Ferrers. A discussion arose on the terms on which permission should be given; but finally the board unanimously granted the request and agreed to make an annual charge of 2s. for each pole erected on the highways in their district.

THE MAQUAY BATTERY.—The battery is a modification of the ordinary double fluid bichromate. There are three peculiarities, claimed as improvements, in its construction. (1) The positive plate consists of an alloy of zinc, tin, lead, and mercury, 95 per cent. by weight being zinc. By the use of this alloy it is claimed that no further amalgamation is necessary, and that entire absence of local action is secured. (2) The porous pots are constructed from a mixture of two parts of carbon dust to six parts of the usual material from which cells are made. In this way the internal resistance of the cells is considerably reduced. (3). Simple means are provided for charging liquid, and also for absorbing the acid fumes. It seems not unlikely that this battery is about as good as any other bichromate battery at present in the market.

EXCHANGING TELEGRAPH CLERKS.—M. Granet, the Minister of Posts and Telegraphs, is just now endeavouring to give effect to an idea which may be of great practical importance in the telegraphic world. It frequently happens that travellers in foreign countries find the greatest difficulty to make themselves understood at telegraph offices, either on account of their own ignorance of the language of the country in which they happen to be, or because of the want of clerks conversant with the language which the travellers themselves speak. To obviate this difficulty M. Granet has been making overtures to the telegraph authorities with a view to sending to England say twenty of the most intelligent French telegraphists in exchange for a similar number of English ones. The same system, of course, if it is favourably entertained, will be carried out in other countries.

CANTERBURY CATHEDRAL ORGAN.—According to a contemporary, the new organ now being constructed at Canterbury Cathedral by Messrs. Willis will be, when completed, in every way worthy of the grand old edifice of which it is to form a most important part. The entire instrument will be operated by electricity, the supply being derived from a battery which is being placed in the old singing school. The length of the cables conducting the electric currents average 120ft. from the console (or keyboard) to the pneumatic levers operating the valves of the sound boards. The organist will occupy a raised position in the second arch of the north aisle, just over the spot where the old instrument was played, his manipulation of the keys being flashed by means of electricity through the 120ft. of cable to the action of the instrument in the triforium above. The organ will be blown by four men in the old singing school. The whole of the patents employed in the pneumatic and electric action are the invention of Messrs. Willis.

GALVANI'S EXPERIMENT ANTICIPATED.—We give the following upon the authority of Mr. A. Platz, who is writing in the *Electrical World* upon the "Electro-Therapeutics":—In a book published by Swammerdam toward the end of the seventeenth century, under the title of *Biblia Naturæ*, the author relates the following experiment made by him in 1678. He states that he had the honour of exhibiting his experiment before the Grand Duke of Tuscany. To a nerve projecting from a muscle placed in a glass tube was fastened one end of a fine silver wire, while the other end was attached to a piece of copper, which was inserted in the tube in such a manner that the wire passed freely between it and the glass. When the nerve was drawn up so as to touch the copper the needle immediately contracted. If this account be correct Swammerdam appears to have anticipated Galvani's discovery by more than a hundred years. As Mr. Platz observes, it was surely through a kind intervention of Providence that the science escaped the name of "Swammerdamism."

EASTERN ELECTRIC LIGHT COMPANY.—All the stock in hand, says the *India Engineer*, and good-will of this company, which was started in Bombay about five years ago, and which was known under the name and style of the Eastern Electric Light and Power Company, was sold on June 24. About two years ago the company, as first established, sold the property to Premchund Roychund, who did not, however, pay the value, and the property did not consequently pass from the hands of the original owners. Premchund Roychund started the business which he had secured under the name of the Bombay Electrical Company, and then made an attempt to dispose of it. He was frustrated, however, by an injunction taken out against him in the Hight Court by Mr. C. E. Ashburner, who is the appointed agent of the liquidators. The original owners, seeing no likelihood of obtaining the sum for which they had sold their property, put the same up for sale again on their premises in Moody Bay. An attempt was made by Premchund Roychund to prevent the sale, which was ineffectual. The stock in hand and other materials belonging to the company was estimated lately at three-and-a-half lacs of rupees, whilst it is said that they calculate on getting something like Rs.500,000 for the property, portions of

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which are at Lahore and other parts of India, where the company has branches.

TESTIMONIAL TO H.R.H. THE PRINCE OF WALES. — The Committee of the Royal and Executive Commissions named on the 14th inst. at the meeting which was held at the residence of Earl Granville, had their first sitting on Tuesday, the 20th inst., in the Durbar Hall of the Colonial and Indian Exhibition. It was resolved: That Earl Cadogan be requested to act as chairman, and Col. Sir Owen Tudor Burne, K.C.S.I., C.I.E., and Sir Arthur N. Birch, K.C.M.G., as honorary secretaries. Earl Cadogan having taken the chair, it was resolved: That communications be addressed by the hon. secretaries to the Viceroy of India, the Governor-General of Canada and the Governors of the various Colonies and Indian Presidencies informing them of the movement. And it was further resolved:—That subscriptions not exceeding the limited amount of £2. 2s. each, might be sent to the hon. secretaries, Prince of Wales Testimonial Committee, Bank of England, Western Branch, Burlington Gardens, London, W.; to the Bank of England, E.C., or to any Provincial Branch of the Bank of England. The following noblemen and gentlemen were named as a sub-committee to carry out the details of the scheme:—The Earl Cadogan, the Earl of Rosebery, Field-Marshal the Lord Napier of Magdala, G.C.B, G.C.S.I., the Lord Mayor of London, the Right Honourable Sir John Rose, Bart, G.C.M.G., Sir Robert G. W. Herbert, K.C.B.

CABLE TO WEST AFRICA. — Sierra Leone has now been brought into direct telegraphic communication with London by the African Direct Telegraph Company's cables by way of Lisbon and St. Vincent (Cape de Verd). The following messages have passed to and from her Majesty the Queen:—"Administrator Hay, Sierra Leone, to the Right Hon. the Secretary of State for the Colonies. Sierra Leone, July 13, 1886. At an entertainment given to celebrate the opening of telegraphic communication between Freetown and England by the African Direct Telegraphic Company, I was requested to transmit through your lordship the following loyal address to Her Majesty:—'The inhabitants of Sierra Leone, celebrating this day the establishment of telegraphic communication between England and Her Majesty's African settlements, desire to express to Her Majesty their profound loyalty to her, and their gratitude for the fresh proof of her royal interest evinced in the welfare of her settlements by her promotion of this important means of communication. They hope that the cable may contribute to an increased interest being taken in the development of the resources of this continent, and to a larger exertion of the benign influence of Her Majesty's Government on its destiny. They pray that you will convey to Her Majesty this expression of their sentiments.'"—Reply: "Earl Granville to the Governor of Sierra Leone. London, July 24, 1886. Referring to your telegram of July 13, Her Majesty commands me to convey her cordial thanks to you and her loyal subjects for their address."

TECHNICAL EDUCATION.—The City and Guilds of London Institute for the Advancement of Technical Education have issued their report on the technological examinations of 1886. The eighth annual examination in technology was held on the evening of May 26th, and on the afternoon of May 29th. The afternoon examination was held to enable candidates in weaving and pattern designing and the textile fabrics to work by daylight. There was a large increase in the number of candidates who presented themselves, and a satisfactory increase in the number of those who have passed. In 1885, 3,968 candidates were examined, of whom 2,168 passed. In 1886, 4,764 candidates were examined, of whom 2,627 have passed. Examinations were held in 48 subjects. Applications for examination were received in all the 49 subjects, but as only one candidate presented himself in sugar manufacture, in accordance with the regulations of the institute no examination was held in this subject. Last year examinations were held in 42 subjects. The subjects in which there has been the greatest increase in the number of candidates are mechanical engineering, plumbers' work, electric lighting, and gas manufacture. One new subject was this year added to the list, viz., brickwork and masonry, in which 99 candidates came up, and of these 57 satisfied the examiners. From the returns furnished in November last, it appears that 7,660 persons were receiving instruction in the registered classes of the institution, as compared with 6,396 in the previous year.

THUNDERSTORMS IN EAST KENT.—*The Times* of July 26 reports that during the past few days a series of thunderstorms have occurred in East Kent, and various incidents are reported. Farm buildings at Herne, near Canterbury, were set on fire by the lightning, and damage done to the amount of about £250. The property, which belonged to Mr. Thomas Ashenden, of Canterbury, was fortunately insured. At Moxton the wife of a retired Dover tradesman, while standing at the door of her house, was rendered insensible by a blinding flash, and continued so for several hours. A man named Kettle, who took refuge under the verandah of the Maidstone and Ashford Railway Station at the latter town, had a peculiar experience. He was wearing a steel pin in his cravat, and fancied that a flash of lightning played about it and that he smelt sulphur. He, however, thought nothing of the matter until he got home, when the discovery was made that the bright steel had been turned black. The cravat, a woollen one, was singed where touched by the pin. Besides these a number of other casualities have been reported. At a place near Youghal five cows were killed by lightning. There were 40 cows in a field, and two of those killed were grazing close to the fence, against which they fell, and were found in a standing position, their limbs having become quite rigid. Where the lightning struck the ground it was much torn up. As two of the Lancashire and Cheshire Telephone Company's men, from Bolton, were lifting a telephone post on to a waggon near the Lancashire and Yorkshire Railway Station, Hindley, they were struck by lightning. Another man who was assisting them was using a steel bar, which attracted the lightning, and it travelled from the bar to the earth wire attached to the pole, afterwards knocking the man from the waggon. Fortunately the men escaped uninjured.

LIGHTNING RODS.—A correspondent, writing to the *New York Sanitary Engineer*, says:—"You state that glass insulators are dangerous. I would beg to mention the following facts:—We have a great many buildings in this city with lightning rods. Very many of these rods are put up with glass insulators, but several buildings have still the old-fashioned 1in. square iron rod secured to the walls with ¼in. iron staples without any insulation. Now I know of two buildings with this old-style rod that were struck by lightning, and in both instances the current left the rod and followed the staples, and considerable damage was done to the buildings. I have yet to hear of a single instance where any damage was done where rods with glass insulators were used. If glass insulators are dangerous, why do all the electric light, telegraph, and telephone companies use them on their wires?" The editor's reply to this is as follows:—"We think the buildings provided with the old-fashioned rods were struck, not because they did not have glass insulators, but because the ground connection and possibly the rod itself were defective. The ground connection is a very

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important part of a lightning rod, and one to which sufficient attention is not always paid. Where the electricity follows a staple instead of the conductor, it is pretty clear that there is something faulty with the latter below the staple. The great majority of evidence goes to show that insulators are useless, or worse. This was the conclusion of the Lighting Rod Conference, composed of members of the Meteorological Society, the Royal Institute of British Architects, the Society of Telegraph-Engineers, and the Physical Society of England. If our correspondent wishes to inquire further into this matter, we refer him to the report of the conference mentioned, published in 1882, and also to Anderson's 'Lightning Conductors,' third edition, 1885. Electric light, telegraph, and telephone companies employ dynamical electricity, while that of lightning has the properties of frictional electricity."

EDISON-HOPKINSON DYNAMOS AT THE COLINDERIES.—One of the most important elements which have conduced largely to the success of the electric lighting at the Exhibition is that in place of an enormous variety of dynamos of all types the lighting has been divided into three or four large groups, each worked by dynamos from one maker. The dynamos for the whole of the internal incandescent lighting have been supplied by the Edison and Swan Company, and are of the Edison-Hopkinson type, manufactured by Messrs. Mather and Platt, of Manchester. There are in all eight machines, but only six are at work, the remaining two being spare machines available for any work required of them. Four are the 10in. long size, for an output of 105 volts, 320 amperes, at 750 revolutions per minute, three of which are employed for lighting Old London, the Hong Kong Pavilion and Tea Gardens, the vestibule, and the Indian Palace Sections, while the fourth is run at a higher speed to give 130 volts, and is used for charging the E.P.S. accumulators. It was on machines of this size that the efficiency experiments were made, which we referred to and commented upon in our issue of 5th and 12th March, 1886. We then showed that a commercial efficiency of over 93 per cent. had been attained, and the satisfactory working of the machines at the Exhibition confirms the opinion we then expressed, for good efficiency shows itself not only in economy of power, but in good lasting qualities, as power wasted is always more or less destructive. Two of the remaining machines are for an output of 55 volts, and 280 amperes, at a speed of 850 revolutions per minute, and are employed in lighting the Exhibition dining rooms. One of these is the same machine which underwent the special test of three weeks' uninterrupted run, the particulars of which we also gave in our issue of 24th January, 1886. The whole installation is a fine display of the Edison-Hopkinson dynamo, which cannot but attract considerable attention.

REPORT ON UNDERGROUND WIRES.—The report of the New York Electrical Subway Commission has just been issued. The commissioners, after careful deliberation, have formed the opinion that as a comprehensive tunnel scheme would be too expensive, the most practical solution will consist in the construction of a conduit in which the wires can be drawn in and out. They recommend asphaltic concrete as the material best suited for the construction of such a conduit. This conclusion has only been arrived at after a series of careful experiments conducted by Dr. Ledoun upon the behaviour of this material when subjected to the action of heat, salt water, coal gas, water gas, and other corrosive agents. Its behaviour under these conditions proved to be remarkably good. In no case did any appreciable chemical action take place, neither does it become soft at any temperature to which it is likely to be subjected in practice. The only other materials at present in the field which are at all likely to find favour in future are iron and creosoted wood. With regard to the former it is open to several objections. Iron when buried under ground is not nearly so durable as the concrete; its cost is at least three times as great per lineal foot for the same capacity; and even apart from these disadvantages it is decidedly preferable to make use of an insulating material. Creosoted wood has found favour with the Brooklyn Commissioners after a trial extending over several months, but it has been objected to in New York on the ground that it is impossible to make a wooden conduit either gas-tight or water-tight. Another objection is that gutta percha insulation is attacked by the creosote. In Brooklyn this difficulty is overcome by covering wires with an outer casing consisting of an alloy of lead with a small percentage of tin. This alloy has been found to resist the attacks of all the gases and liquids which find their way into the conduit. However, the New York Commissioners are probably right in preferring to use a material which will permit their conduits to be constructed absolutely gas and water tight.

WHAT "THE TIMES" SAYS.—"During the last ten years M. Marcel Deprez has been engaged in experiments connected with the transmission of force by means of electricity. The Rothschilds some time since provided him with an unlimited credit to prosecute his researches at Creil, under the inspection of a commission of 38 men of science. On Friday the commission met to hear a report on the results at present obtained, drawn up at their request by M. Maurice Lévy. This report was unanimously approved. It appears from it that we can now, with only one generator and only one receptor, transport to a distance of about 35 miles a force capable of being used for industrial purposes of 52 horse-power, with a yield of 45 per cent., without exceeding a current of 10 amperes. When the amount of force absorbed by the apparatus used to facilitate the recent experiment, but not required in the applications to industrial purposes, is added, the yield will be nearly 50 per cent. The commission certifies that the machines now work regularly and continuously. The maximum electromotive force is 6,290 volts. Before the construction of the Marcel Deprez apparatus the maximum force did not exceed 2,000 volts. The report states that this high tension does not give rise to any danger, and that no accident has occurred during the past six months. The commission is of opinion that the transmitting wire may be left uncovered on poles provided it be placed beyond the reach of the hand. It estimates at nearly £5,000 the probable cost of the transmission of 50 horse-power round a circular line of about 70 miles. This price would, however, be much diminished if the machines were frequently constructed. The commission, in the name of science and industry, warmly congratulated M. Deprez on the admirable results which he had obtained, and expressed thanks to the Rothschilds for the generous aid extended to the undertaking." We may add to *The Times* account the satirical comment of another prominent French electrician, who is reported to have said that M. Marcel Deprez had succeeded in making certain wealthy Frenchmen believe (1) that the transmission of energy electrically was important; (2) that M. Marcel Deprez had invented the system of electrical transmission of energy; and (3) that his system was a gigantic success from every point of view. From this it will be gathered that we are not so satisfied that M. Deprez has succeeded in solving the problem. We are rather of opinion that the real problem has not been attacked.

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ALTERNATING AND INDUCED ELECTROMOTIVE FORCES.—III.

BY W. H. SNELL.

In the last paper we considered the form of the variation undergone by the self-induced and resultant electromotive force when the value of the coefficient of self-induction is changed. We will next assume that L is constant, and vary the resistance.

Fig. 4 represents the case when $\frac{2\pi N}{T} = 1$; $L = N$ and $R = 2$.

It thus corresponds to the conditions of Fig. 1, except that the value of R having been made twice as great, the current curves no longer coalesce with those belonging to the electro-

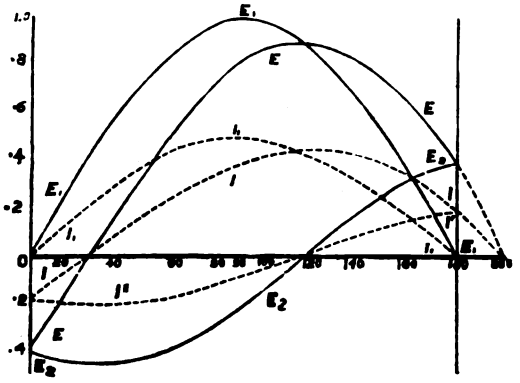

FIG. (4) $\frac{2\pi N}{T} = 1$; $R = 2$; $L = N$.

motive forces. The values of E_1 and E_2 remain the same, but the ordinates of the corresponding currents are only one-half as great. Moreover, as we have already seen, the tangent of the angle of retardation varies inversely with the value of R. In Fig. 1 we had

$$\frac{2\pi L}{RT} = \tan\phi = 1.$$

Hence, $\phi = 45°$.

In the present case,

$$\tan\phi = \tfrac{1}{2}$$

and therefore $\phi = 26°\cdot36'$.

The variation which this angle undergoes as the resistance of the circuit is changed can, however, best be seen in Fig. 5.

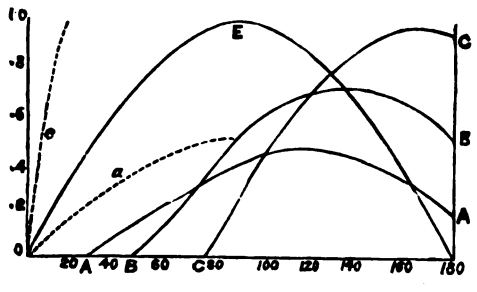

FIG. 5.

Here curve E represents as before the impressed E.M.F., and L is again made equal to N. The other curves correspond to the resultant currents for the respective values of R, which are given in the following table. These curves are most conveniently obtained from the formula of equation (9), and the reduced form of the equation corresponding to each case is also given.

Curve	R	ϕ	Equation
A	2	76°	$\frac{4}{17}(\sin\theta - 4\cos\theta$
B	1	45°	$\frac{1}{2}(\sin\theta - \cos\theta)$
C	0·25	26·36′	$\frac{1}{5}(2\sin\theta - \cos\theta)$
	$\frac{2\pi N}{T} = 1$		$L = N$

The dotted lines marked *a* and *c* represent portions of the curves corresponding to the cases of A and C when the self-induction has been made zero. Curve B would in this case coalesce with E. If we compare the curves A with *a*, B with E, and C with *c*, it will be evident that as the resistance of the circuit increases the effects of self-induction become less and less apparent.

We have next to consider the effect of a variation in the speed of rotation. In the first place we know that E will vary directly with the speed, or inversely with the time T. But if we look back at the equation for the resultant current in the form in which it was first obtained, namely,

$$I = \frac{2\pi N}{RT} \frac{(\sin\theta - \frac{2\pi L}{RT}\cos\theta)}{\left\{1 + \left(\frac{2\pi L}{RT}\right)^2\right\}}$$

it will be seen that R and T always occur together in this formula. Consequently Fig. 5 may also be taken to represent the effect upon the resultant current of a variation in the speed of rotation under the condition that R remains unchanged. If we then take E and B as corresponding to the case when all the terms have unit value (as in Fig. 1), then curve *a* will represent the resultant current for the case when the speed has been reduced to one-half, and *a* will be the corresponding

FIG. 6.

curve of electromotive force. Similarly, curve C will represent the case when the speed has been increased fourfold, and *c* will be a portion of the curve of electromotive force. The maximum ordinate of curve *c* will occur at 90°, and will be four times the height of the ordinate of E. From this figure we may observe how rapidly the effect of self-induction increases with the speed of rotation.

We have not completed the examination of the *form* assumed by the curve of an alternating current under varying conditions. We shall consider next the rate at which work is done by an alternating current under different conditions, and what must be the value of the continuous current which would do equal work in the same time.

And, in the first place, it will now be convenient to establish the convention that for the future the symbol which we employ for an alternating current shall have a numerical value equal to the *maximum* ordinate of the corresponding current curve. Then, strictly speaking, the equivalent continuous current, that is, the continuous current which will in the same time convey the same quantity of electricity through any cross section of the circuit will be equal to I multiplied by the mean value of the series of all the angles between 0° and 90°. And it can be shown that the latter factor is equal to $\frac{2}{\pi}$. If, therefore, we write C_0 for the equivalent continuous current, we shall have

$$C_0 = \frac{2}{\pi} I; \text{ or } 0{\cdot}637\ I.$$

We shall call C_0 the *true mean value* of I.

It must, however, be observed that this value of C_0 is obtained upon the assumption that E, the impressed electromotive force, is a true sinusoid. If E is a sinusoid, then from the equation for I in its second form (10) we know that the resultant current is also sinusoidal. On the other hand, if, for instance, we could obtain a rise and fall of the current approximating to that represented by the full line in Fig. 6, it would follow that

$$C_0 = I,$$

or, in the case represented by the dotted line,

$$C_0 = 0{\cdot}5\ I.$$

These considerations are not without practical importance under certain circumstances.

But, although the continuous current equal to C_0, as just defined, conveys the same quantity of electricity through a

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given cross section of the conductor in a given time, it is evident that, inasmuch as the work done in the circuit is proportionate to the squares of the current *at each moment*, the rate at which energy is conveyed by the two currents is not necessarily the same. It is also evident that in general I does work more rapidly than C_0. In order to find the value of the continuous current which will do work at the same rate as I, we must obtain the mean of the squares of the values of the alternating current during a given period. It can be shown that the average value of the squares of the series of all angles between 0° and 90° is equal to 0·5. If, then, we write C for the value of the continuous current which does work at the same rate as I, assuming as before that I is represented by a sinusoid, we shall have

$$C^2 = 0{\cdot}5\ I^2$$

$$\text{and } \therefore C = \frac{I}{\sqrt{2}} = 0{\cdot}707\ I$$

We shall call C simply the *mean value* of I.

It follows that in order to obtain the same deflection upon a Siemens dynamometer, or to produce the same temperature in an incandescent lamp, a continuous current must bear the above relation to (the maximum periodic value of) an alternating current.

The relation between the two means is given by

$$\frac{C_0}{C} = \frac{0{\cdot}637}{0{\cdot}707} = 0{\cdot}9$$

or

$$C_0 = 0{\cdot}9\ C,$$

so that in order to obtain the actual quantity of electricity passing per second we must multiply the tabular reading of a Siemens dynamometer by the fraction 0·9.

A STATICAL INDUCTION MACHINE OF THE WIMSHURST TYPE.

A recent number of the *Journal de Physique* gives the following description of this machine. It is composed of two glass discs of 700mm. diameter, which are capable of rotation round a common axis perpendicular to their faces. These two discs rotate in opposite directions. Each of two horizontal combs, supported by glass feet, embraces both discs, one on each side.

Each of these discs carries 12 sectors formed of metallic leaves. These sectors have at their centres metallic wafers, meant to rub against the tinsel brushes carried by two diametral conductors, of which one is in connection with each disc. These conductors are inclined at about 45° to the line of combs.

The conductors or poles of the machine are united to the combs, and pass through the glass case by means of copper cylinders armed with balls and insulated by ebonite.

It is not easy to explain in a rigorously satisfactory manner the play of inductive influences which takes place in this machine. Nevertheless, by adopting the cylindrical mode of representation devised by Bertin to show the manner of action of the Holtz machine, one may form a cycle of operations which suffices to show how the phenomena of induction are continuously produced.

Let us suppose that the two plates are represented by two concentric cylinders, on the surfaces of which are placed metallic bands corresponding to the sectors. These cylinders have a rotatory movement round the axis, of which 0 is the projection, and in the direction of the two arrows. The two diametral conductors are represented by A B and C D, and the two combs by E G and F H.

If an electrified body is brought near A induction takes place, and the bands of the external cylinder become charged through contact with the brush.

The charged bands arrive facing the brush C. There they act inductively on the conductor C D, supposed insulated. The bands of the internal cylinder become charged and are transported before A, where they also act inductively.

The bands of the external cylinder, after having passed the brush C, pass successively before the comb E G intended to neutralise them. The ball G becomes charged as the bands are neutralised. The effect of the induction produced in C D has been to charge the extremity D of this conductor and consequently the bands which come into contact with it. The bands come thus charged before the brush B of the diametral conductor A B, which charges the corresponding bands of the external cylinder.

The neutralisation of these charges is effected by the comb F H, whose ball is thus charged with an electricity of contrary sign to that of G.

It will be remembered that the combs serve to neutralise two series of bands belonging respectively to the two cylinders, and whose actions are concurrent. Hence the balls G and H are the poles of the machine.

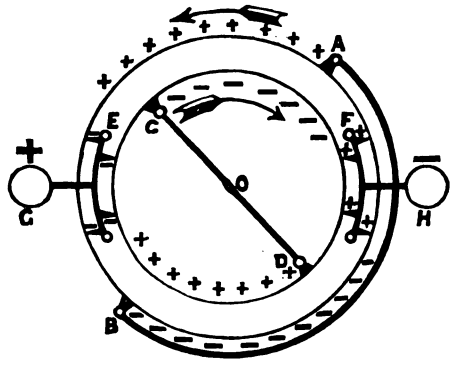

FIG. 1.

If it is supposed that the machine is primed artificially, it can be seen that the accumulation of the charges is produced by the play of inductive influences in the quadrants C O A and B O D.

After the machine has been primed by bringing a stick of excited ebonite into the neighbourhood of A, the action will still continue when the stick is removed. But in this case it can be shown that the action is due to the combs, and ceases when they are united by the earth or by a metallic conductor.

The machine may also be primed by bringing an electrified body near one of the conductors of the combs; but it requires a body more strongly electrified than in the other case.

If the sectors and metallic wafers are made of tin, the machine becomes capable of priming itself, and of acting after a few turns (electricity of contact being developed by the tinsel of the brush and the tin).

After the machine has been primed, the charge of the sectors increases rapidly to attain a certain limit, imposed by the fact that there is limit of potential compatible with the form of the conductor and the nature of the medium, on the one hand, and, on the other hand, by the theoretical diminution of the added charge as the number of operations increases.

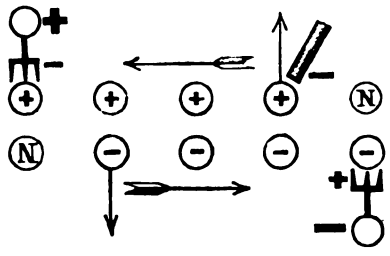

FIG. 2.

Let us represent the active elements of the machine as Fig. 2 indicates, and suppose that the circles, which represent the sectors, have motions of translation, as indicated by the horizontal arrows. The vertical arrows indicate communication with the earth.

The electrified knob is brought near the conductor united with the earth. Let $-m$ be the quantity of electricity which acts inductively on the conductor. $-m$ will induce a quantity $+\alpha m$ (α being less than unity). This quantity αm will be carried off by the sector in contact with the brush at the moment of the induction. It will arrive before the second

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conductor in connection with the earth, and will induce on the sector in contact with the second brush at the instant a quantity

$$-\beta(\alpha m) = -\alpha\beta m \text{ (where } \beta \text{ is less than unity).}$$

The two preceding operations constitute the first cycle of operation. The second cycle commences by the induction on the sector in contact with the first brush of a quantity of electricity,

$$\left.\begin{matrix} +\alpha m \\ +\beta(\alpha\beta m) \end{matrix}\right\} = +\alpha m(1+\beta^2)$$

The 3rd by that of a quantity

$$+\alpha m(1+\beta^2+\beta^4).$$

The 4th by that of a quantity

$$+\alpha m(1+\beta^2+\beta^4+\beta^6),$$

and so on.

It can be seen that when the priming is kept up, one of the factors which expresses the charge is constant, whilst the other forms a rapidly convergent series. Thence, theoretically, there is a limit to the charge.

Suppose that the priming is not kept up, and that after a sector has been charged with the quantity $+\alpha m$, the electrified rod is taken away. The quantity $+\alpha m$ will induce before the second brush a quantity $-\alpha\beta m$, the quantity $-\alpha\beta m$ will induce before the first brush a quantity $+\alpha\beta^2 m$, which in its turn will induce before the second the quantity $-\alpha\beta^3 m$. At the end of the fourth cycle the quantity $-\alpha\beta^{2n-1}m$ will be induced before the second brush. The charge therefore decreases in geometrical progression as the operations increase in arithmetical progression, and the machine is rapidly discharged.

This point is easily verified by putting the combs to earth.

It is hence seen that the combs must help to keep up the action of the machine when the artificial priming ceases, since practically this machine has the power of keeping up the action of itself. In the preceding calculations we have supposed the combs to have a purely passive action, which, as we see, cannot be quite the actual case when they are insulated.

The Wimshurst machine offers sufficient advantages to be employed preferably to all others in industrial applications.

Several trials have been made with these machines for the condensation of the lead vapours of the refining stoves in the depositing conduits, and have given, it appears, sufficiently satisfactory results for them to think of constructing special machines for this purpose.

A WEST AFRICAN TELEGRAPH STATION.

Our correspondent from the West Coast of Africa says:—"By this time your readers are doubtless conversant with what has been and what is being done to connect the effete old world with the swamps and sand heaps of Western Africa by the pioneer company (the West African) and the Direct African Company, which latter acquires the existent sections between St. Vincent and Praia de St. Thiago—190 knots—and from Praia to the junction of the T pieces branching off to Dakar, Conakry, and Bulawa. Thence from that junction, the first section of the new company will extend to Bathurst, and eventually connect the whole of the English ports on the coast, while the pioneer company will confine its operations to the foreign possessions, and terminate its lines at Mossamedes; at least, so I understand, but some of your readers may be later and better informed. The only West African station proper that I was able to inspect was the one of chief importance, namely, Bulawa, an island remarkably prolific in bad smells and, judging by my own experience, very bad fevers. It is probably the hottest and certainly one of the most pestilential spots on the face of the earth, and its very situation, the tortuous nature of the approach to it, is enough to breed at least semi-despair in the heart of every properly constituted human being. It lies amid a multitude of islands, a perfect and seeming interminable labyrinth of mangrove swamps and turbid, drab-coloured water, stretching away to the eastward for about 80 miles. Its population is stated at 5,000, some 50 being by a stretch of the imagination classified as whites, while two are Englishmen, the only English speaking people in Bulawa. Nowhere among these islands (of which Bissao is one) is the water of any depth, and as we steamed slowly along the narrow channel, and occasionally stuck on a sand or mud bank, I could not help thinking what a very lively time the G.P. must have in such shallows, the mean temperature being 83°·5 Fah. Taking, however, the section from Bulawa to Bissao, 41·9 knots, the insulation comes out better than I anticipated, viz., 650 megs. absolute. On landing at Bulawa the heat struck up from the red sandstone path—if path it could be called—as from a furnace, while the sun beat down through umbrella and capacete as if those ordinary useful things had been absent. I had great difficulty in finding the office, but blundered along through the burning sand till a very neat and clean-looking house assured me that I had arrived at the abode of Englishmen. Here I found Mr. Burt, who very kindly and courteously conducted me over the station and cable house. The station was, despite an evident want of furniture, exceedingly well kept, and the apparatus and its general arrangement showed signs of care and industry. The lines to Conakry and Dakar and Praia de St. Thiago are worked on the mirror system, and those to the Island of Bissao and to the cable house on the Morse system. There is also one spare Morse instrument. I commiserated the poor fellows here exceedingly, although they protested with a pitiful attempt at cheerfulness against the assertion that the place was unhealthy. I have visited and have lived in telegraph stations in perhaps three-quarters of the globe, and I take this opportunity of saying that Bulawa is the worst I ever heard of or saw. The West African Telegraph Company is, I believe, actuated by an honest desire to do its best for its *employés* in these pestilential West African ports, and in this belief I offer them some advice, founded on long experience, and dictated by the friendly spirit of telegraph brotherhood. In justice to the staff, it must be made a floating one; it is not difficult to keep the few men at the bad places almost constantly shifting about, and it will pay to do so. Say, for instance, the head-quarters were at St. Vincent, or even St. Thiago, and a change were made every three months, that is three months at St. Thiago and three months at Bulawa—*ad infinitum*. There are two or three mails every month, and an arrangement could be made to carry them at reduced fares. I was on shore at the latter place for two hours, and I am not yet free from bilious fever, hardened as I am to African climates. The fairly good health at present enjoyed by the poor fellows at Bulawa speaks very highly for their temperance, courage, and carefulness; but it cannot last, and I will tell you why. They have not yet experienced a rainy season; the island is surrounded by mangroves, and the sun is ever a ball of molten brass. When the rains die away the sun is at its fiercest, and the miasma will rise from the swamps in a death-dealing cloud. West African Company, you must shut up that cable-house, put in a tank, join the cables through and remove the testing apparatus to the station. If the superintendent is to test from there, or the staff is to watch for 'ship' in the event of a break, you you will lose more men than you have miles of cable. The cable house is in a mangrove swamp, and the black fœtid waters actually pass under it. This is a very serious mistake, and one that should be rectified without loss of time. A relieving superintendent should also be appointed for this coast, a capable electrician, speaking the language, and able to turn his hand to anything. I should station him at St. Vincent or St. Thiago. Bulawa, Mr. Burt told me, is about the best station on the line! What, in the name of goodness, can the others be like? Bissao, however, is probably worse. The office is right on the beach, which is the receptacle for all the filth in the place, and fevers—enteric and intermittent—are said to be rife there. At Conakry, some eighty miles north of Sierra Leone, a house is being built for the staff, and as this place is a French settlement it may be somewhat better than the two I have particularised. As regards other stations, I cannot speak with any degree of certainty; but my remarks *re* Bulawa and Bissao fall short of

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the truth, and I commend them to the notice of those who have the remedy in their hands. The pay is very good. Organisation is what is wanted, and I can easily understand that at the outset it has been very difficult to thoroughly arrange and constitute the lines. The duties, I think, might also be bettered at the intermediate stations. Why not, instead of breaking in every alternate hour, take example by the Eastern and South African Telegraph Company, and break in every four hours, say at 8 a.m., 12 noon, 4 p.m., and 8 p.m.? This gives the men a good rest, and in the event of sickness—only too common a contingency—enables the healthy and solitary individual to get through the whole of the work of the station without difficulty. It answers very well on the east coast. According to the terms of the concession, the cables must be through to St. Paul de Loanda, where I am at present, by the 4th of next December. The southern ports, and more particularly Mossamedes, are comparatively healthy. At Benguella and Mossamedes little difficulty will be experienced in arranging offices, &c., but a house at Loanda should be seen to at once, as the advent of the railway has rendered them scarce in the lower city, and almost unobtainable in the upper city. Anywhere between the Forte de Penedo and the Forteleza de St. Miguel, the lower city is very unhealthy; not excessively so, but the drainage is bad, and typhus is not rare. The upper city is very salubrious; but it will be difficult to get the cable up there, and an office on the flat below is not advisable. Perhaps the best place is on the north-east side of the Forte de Penedo, where the water is deeper and where the main office might be situated; this would be near the new quay and the railway terminus; while for the convenience of the authorities and commercial people an aerial line might be run into the town about 1½ mile distant."

CORRESPONDENCE.

SHOT FIRING IN MINES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I should like to correct two rather misleading statements that appear in the article on the above subject in your current number.

The flame that is so dangerous in firing—that is, from the powder, and I believe it is rarely present except in the case of a blown out shot, as it is called, where the energy of the explosion is not sufficient to break down the coil and fire inwards—expends itself outwards, blowing out its tamping and producing a flame outside. Then, if any inflammable gas be present, it may be ignited, or if, as more frequently happens (unless special precautions are taken), there be a mass of coal dust near, the explosion may raise a cloud, which, being itself inflammable, may communicate the flame to some part of the mine where there is gas present, and so cause one of those disastrous explosions which have unfortunately been somewhat frequent of late.

Again, the danger of the Beckford fuse lies in the fact that it cannot be relied upon to fire or not fire and have done with it. It may smoulder for a long time, and then when disturbed by the miner, who imagines that it is quite safe, suddenly acquires sufficient energy, owing to the disturbance, to fire the shot, and perhaps seriously injure the man who has meddled with it. For this reason it is usual in mines where this fuse is used not to allow a man to go near his shot for several hours after he has ignited his fuse. The enormous advantages which any system of firing by means of electric currents presents must be self evident; but I hardly think we need go as far as Paris for apparatus, when we have simpler, and, in my opinion, more efficient apparatus at home. Several kinds of fuzes have been in the market for years, but I think the palm for simplicity, cheapness, and special adaptability to the work which they are to do must be given to those of the Electric Blasting Company, of Cinderford, of which Mr. Frank Brain, a mining engineer, and the manager of the only colliery in this kingdom where electric transmission is used, is the managing partner.

The fuzes consist simply, for powder, of two wires with a composition, between which the passage of an electric current will generate sufficient heat to ignite the charge. It is protected by a wooden case from the effects of tamping, and the leading wires are moderately stout and well covered, for the same purpose. For dynamite the detonator is secured to the end of a flat stick, in the sides of which grooves are cut to receive the wires, which are thereby protected from damage, leaving the ends free for connecting. The sticks are made in different lengths, according to the depth of the holes for which they are required, so that a man can take a bundle under his arm, and shoot one into each hole as he passes. The fuzes are connected to each other, and to the wires leading to the exploder, which is, of course, at a safe distance, and in a safe part of the mine, in the usual way. I think the above is simpler and likely to be more certain in action than the Ruggieri, judging from the description contained in your article.

I notice, too, your description of an apparatus for testing these fuzes. I should be glad to know if the writer of the article, or any of your readers, have tested the apparatus personally, as, with a telephone in circuit, the distinction between a resistance of one or two megohms and such infinity as might be expected under the conditions named looks to me too like laboratory work for factory use.—Yours, &c.,

Cardiff, July 27, 1886. SYDNEY F. WALKER.

AMPERE'S RULE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In regard to Ampère's rule and the earth's magnetism it may be remarked that, if, as is supposed, the earth has an absolute negative charge, the carrying round in the direction of the earth's rotation of this negative charge would, in accordance with Rowland's experiment, if the rotation were sufficiently rapid, produce a magnetic force which would have the same sign as that due to the earth's magnetism.

According to Maxwell's ideas it is the absolute velocity of the electricity, not its relative velocity, which produces the magnetic effect, consequently the effect on the magnet would not be cancelled by the fact of its being also carried round.

It might be urged that on this theory we do not know what the effect of electricity absolutely at rest is, since when we experiment on what we call statical electricity it is moving in space with the same motion as the part of the earth on which we stand. That this motion is not sufficiently great to have any effect is seen from the fact that statical electricity has no effect on a magnet.—Yours, &c., J. M. CHAMBERS.

July 23.

THE INCANDESCENT LAMP DISPUTE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With reference to the letter published in your issue of July 16, we beg to enclose the reply which we have received from the Edison and Swan Company.—Yours, &c.,

MUIR AND MAVOR.

Glasgow, 10th July, 1886.

Reply from the Edison and Swan Company.

"I beg to acknowledge the receipt of your letter of the 9th inst., and to express my regret that, acting under misapprehension, I should have sent to Mr. Holden the letter of 1st inst., from which you quote. I have no hesitation in saying that I very greatly regret that I should have written to Mr. Holden unnecessarily. I do not share your opinion that my doing so can have any prejudicial effect on your interests; but in order to put the matter quite right, I write to Mr. Holden by this post, expressing my regret that we should have troubled him in the matter. I hardly know what satisfaction you will receive from sending your letters to the electrical papers, but that is manifestly a matter for you, although it is customary when a frank expression of regret is made to accept it."

[CORRESPONDENCE *continued on page 237.*]

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, *Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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CABLE STATIONS.

The announcement a few days ago that the West Coast of Africa is now in direct telegraphic communication with London was perhaps chiefly interesting because of the grateful and loyal address which accompanied it from the inhabitants of that geographical area of which SIERRA LEONE is regarded as the capital. To them the laying of the submarine cable, so long desired, but so little expected, is a fresh proof of "Her Majesty's interest" in the welfare of her settlements, and a new ground for hoping that the "benign influence" of the British Government will be more largely exerted for their development in the future. To us the event is merely an evidence of the growing commercial importance of localities now for the first time connected by telegraph to the Mother Country, and perhaps also of the political interests which have sprung into prominence in those regions during the last two or three years. It is a good stride towards realising that girdle round the Dark Continent which the growth of our African possessions and responsibilities will one day demand. Besides the political objects which this and similar cables in that part of the world are intended to serve, there is little doubt that the expectations of the settlers will not be disappointed in the development of the vast resources of the interior by expediting the means of communication with the manufacturing and commercial centre of the British Empire.

Some particulars with reference to the route and position of the DIRECT AFRICAN CABLE will be found in a letter from an esteemed correspondent which we publish elsewhere, as well as of the WEST AFRICAN—which he calls the pioneer—Company's cables. According to our informant, the first-named Company, which has laid the sections between St. Vincent (Cape de Verd) and St. Thiago, and their branches to Dakar, Conakry, and Bulawa, extend their operations to Bathurst, and will eventually connect the whole of the English ports on what is technically designated the West Coast. The pioneer company is of longer standing, but has hitherto confined its operations to the foreign settlements, though the undertaking is—as usual—an English one, and worked by English operators. Our correspondent, who is not connected in any way with the telegraph service, though he has seen a great deal of it in former years, paid a visit to at least one typical "station" of the WEST AFRICAN Company, and has given us a graphic, if not picturesque, account of what he saw there. Being untrammeled by official responsibility, he speaks his mind freely, and is liberal with suggestions which only an outsider would venture to offer. But we have no reason to doubt the substantial accuracy of his account; on the contrary, we know that it could be matched by descriptions from other parts of the cable-world besides West Africa, though the dangers and hardships may be of a different kind; and as our correspondent has been "roughing it" the best part of his lifetime, he is not the man to have formed a fastidious ideal of the essentials for life and health in foreign climes.

The picture he has drawn of the actual condition of the Bulawa station is instructive from at least two points of view. First, as concerns the servants of the Cable Companies; next, as touching the companies and the public who patronise them. To the general public, a submarine telegraph company is merely an ordinary commercial concern, whose expenditure can be estimated by the common rule of business establishments, and whose charges ought to be regulated on similar principles. Now, setting aside all the risks peculiar to submerged cables, but with which we are not concerned at present, there are the less known, but hardly less serious, risks attending their staffs of operators and superintendents at foreign stations. The hardships they undergo, and the casualties to which they are liable are, judged by ordinary standards, altogether disproportionate to the services they perform, which are neither military in obligation nor governmental in point of honour. Men who voluntarily run such risks without hope of reward or distinction have to be paid handsomely; and unless they are to be speedily swept away by epidemic or something worse, which of itself would be a new charge upon their employers who must train and transport fresh men to fill the vacant places, these valuable lives must be cared for, must be shifted about periodically, and must have long leave of absence at not infrequent intervals. In short, the expense of maintaining a thoroughly efficient staff abroad, especially at isolated stations, and affording the necessary relief and relaxation, is far greater than the public suppose, and must always be taken into account when criticising the income and charges of Submarine Cable Companies.

In the long run it will pay the companies to remunerate their servants liberally. Even at Bulawa there are no complaints on that score. But something more than pay is needed, something without which high wages are simply thrown away. From the early days of deep sea cable enterprise this fact has been recognised by shipping out to the expatriated and disconsolate bands of telegraphists such luxuries as billiard tables, cricket utensils, and a good stock of books, with most excellent results. Rates were not then what they are now, and the best we can say to those who possess such treasures is "take great care of them." We have hinted at something worse than epidemic; and there are, indeed, ailments bred of solitariness and *ennui* such as overtake the Queensland shepherd, to escape from which the deadly grip of a Gold Coast fever would be a merciful visitation. Next to recreation and social companionship, locality is of most importance. It has always been a

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difficulty to hit upon a spot for the "station" which shall be at once healthy and handy. Handiness has in reality been the first consideration, though with a few such experiences like that described by our correspondent in the mangrove swamps off Cape Coast it ought soon to be quite secondary. Not where men can survive for a time, but where they can live in moderate comfort and maintain enough vitality to be relied upon for a considerable portion of the year, is the truly economic as well as the most humane thing to be discovered. In its way Bulawa is a sample of "stations" both East and West which are by no means exceptional. There is not much to choose between the fogs of Newfoundland, the simoons of Arabia, and the miasma of Sierra Leone.

We cannot leave this subject without a tribute of admiration to the brave men whom the Cable companies are proud to claim as their servants all over the world. Bulawa furnishes us with a type of *employé* more common, it is to be hoped, than the station at which a patient, dutiful and almost solitary life is being spent without complaint and with no thought of desertion. Englishmen have peopled and almost subdued the world by their physical capacity for adapting themselves to every climate; but none the less are those heroic qualities deserving of the highest praise which keep men at their posts under such trying circumstances as almost everywhere prevail where cables are landed on distant and foreign shores. It is greatly to be hoped that neither the pressure of competition nor the clamour of an unthinking public at home will so far impoverish the cable companies as to tempt them to overlook the well-being of their devoted servants abroad.

HEATING FOOT-WARMERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your last issue attention is called to "an improvement in the plan for heating foot-warmers for railway carriages," stated to have been introduced by Mr. Tomasi, by causing a current of electricity to produce an increase of temperature in a solution of acetate of soda.

The heating of trains by electricity has, without doubt, a great future, and the various modes of carrying it out are of general interest. You may therefore consider it right to call attention to the fact that the mode alluded to *as novel* was fully described by me in 1883 in my patent (also published in France) for apparatus for electrical heating, No. 4,961, fol. 3, lines 44-46:—"Apparatus constructed as described may be employed for heating purposes generally; for example, it may be used to heat reservoirs or holders of water or of chemical salts—such, for example, as may be used for foot-warmers for railways." Acetate of soda was at that time well known as a suitable chemical salt for retaining heat for foot-warmers.—Yours, &c., JOHN S. SELLON.

The Hall, Sydenham, July 28, 1866.

AN EXPLANATION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: We note that in your issue of the 23rd inst. you mentioned that we are supplying two 80v. 500 amp. machines for the Prudential Assurance Company. Although we believe these machines are for the company above mentioned, yet we are supplying them to the Electrical Power Storage Company, who are the contractors for carrying out the installation. We shall be obliged if you will kindly insert this correction in your next week's issue.—Yours, &c., R. E. CROMPTON & Co.

London, E.C., 27th July, 1886.

INFORMATION WANTED.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: There is an important error in my letter under the above heading, as printed in last week's issue. The third line should read "Optician to *His* Majesty," as I have reason to believe the machine is quite 100 years old, if not more.—Yours, &c., T. H.

July 24, 1886.

MAGNETIC RESEARCHES.

BY PROF. G. WIEDEMANN.

(*Concluded from page 219.*)

From the preceding we may assume that in the action of any torsional forces (which may also be zero), the molecules are displaced and rotated in accordance with the deformation produced by these forces, and afterwards, upon the action of other forces, pass from their first positions of equilibrium into others, which, however, are conditioned by the first. If, then, the molecules are greatly displaced and rotated by a more powerful torsion, they still partially retain this displacement and rotation upon the action of a feebler force; whilst, conversely, upon changing from a feebler to a stronger torsional force, the latter is unable to produce so great a displacement and rotation of the molecules which lie nearer their neutral position.

A similar behaviour in the case of wires is shown by an experiment of H. Tomlinson's*, in which, however, only small differences were observed between loading and unloading.

VI. The behaviour of iron bars in temporary magnetisation, by increasing and decreasing forces, is exactly similar to the mechanical behaviour here described. Messrs. Righi, Fromme, and Warburg have shown that if an iron bar is successively magnetised by forces a, b, c, b, a, of which $a<b<c$, the temporary moment M'_b, corresponding to the force b with decreasing magnetisation, is greater than the temporary moment M_b, corresponding to the same force with increasing magnetisation. Warburg has ingeniously deduced from this the behaviour of a magnetic needle vibrating above an iron plate.

In order to investigate whether this phenomenon occurs only with the first increasing and decreasing magnetisations of the bars, or whether it occurs also after they have attained a permanent condition after repeated action of the magnetising forces, the following experiments were made, in which freshly heated iron bars were magnetised by currents passed round them in such a way that their intensity could be gradually increased up to a certain magnitude and then gradually reduced to zero, so avoiding the influence of all disturbing induction-currents.

For this purpose a special regulating Bunsen's element was employed (Fig. 11). It consisted of a porcelain cylinder

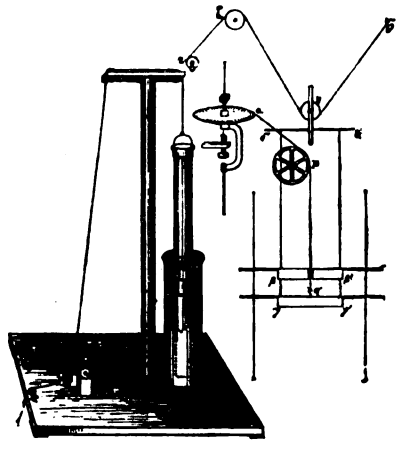

FIG. 11.

36 centim. high and 10 centim. wide, on the bottom of which was cemented a second concentric porcelain cylinder closed at the top, 25 centim. high and 5 centim. wide. This supported

* *Phil. Trans.* Roy. Soc. Lond., 1883, Part I. p. 10 (Exp. V.). Tomlinson, in his experiments, put on the weights by hand without observing irregularities; it seems to me that in the method now described, which was used by me in 1858, better security against accidents is obtained.

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a porous cell 10 centim. high and 5 centim. wide, in which was contained a Bunsen carbon-cylinder provided with a connecting wire, and was filled with nitric acid. It was surrounded by a cylinder of amalgamated zinc 10 centim. high and 9 centim. wide, which was suspended by means of strips of zinc soldered to it from the edges of the outer porcelain cylinder, which contained dilute sulphuric acid. A glass tube 40 centim. long closely surrounded the porous cell and its support, and could be raised or lowered by means of a cord attached to it, which passed over a pulley to a roller and handle. A brass band stretched by a weight pressed against the roller and held it firmly in any position. By this arrangement the current could be increased from nearly zero up to a considerable strength. Of course the same arrangement might be employed as a Daniell cell*.

The current from this cell was passed through a copper-wire spiral 25 centim. long, 2·7 centim. internal diameter, and 7 centim. external diameter, lying horizontally magnetic east and west, 50 centim. distant from the steel mirror of the reflecting galvanometer. The deviation thus produced was compensated by means of the vertical copper ring placed in front of the mirror. A freshly heated bar of soft cast steel, 24 centim. long and 1 centim. thick, was fixed in the spiral, and its momentum determined from the deflection of the mirror. The corresponding intensity of the current was determined as before, by turning down the ring. In order, further, to be able to adjust the current during the temporary magnetisation of the bar to any desired strength, the ends of the spiral were connected, in particular cases, with the quadrants of a Mascart electrometer, the needle of which was charged from a battery of 100 copper-water-zinc elements. Its deflection was read by means of a telescope and scale distant one metre from the mirror attached to the needle.

In the following Tables E denotes the deflection of the needle of the electrometer, M the temporary moment of the magnet, I the intensity of the current measured by lowering the ring.

In the first series of experiments the iron bar was repeatedly magnetised by currents which in each case rose to a definite maximum intensity determined by the electrometer, and were then reduced to zero. The permanent moment was determined in each case after complete cessation of the current (E = 0). The results obtained were as follows :—

(1) E	5	13	13	17	23	17	12·8	9·5	6	0
M	55·5	—	61	157	379	323	278	231	177	99
(2) E	5·5	9	13·2	18	23·5	17·7	12·7	9	5·8	0
M	146	184·6	230·2	291·3	381	323	269	228	184	109·5
(3) E	5·8	9	13	18	23·2	16·7	13	9	5·8	0
M	155	190·6	234·5	301·2	381	309	270·5	228·2	185	113
(4) E	5·8	8·9	13	18	25	17 5	13	9	5·8	0
M	159 2	190	236	296	394·2	322·2	272	229·8	187·5	116·2

and after *ten* similar magnetisations,

(15) E	5·8	9	13	17	23	16·5	13	9	5·8	0
M	173	206	249·3	303	380·5	319	281·5	237·6	194·2	126·2

In another series of experiments a fresh iron bar was repeatedly magnetised to the same temporary maximum moment M_l; then the intensity of the current was decreased to zero, and the permanent moment M read off after complete cessation of the current.

Thus :—

	1.	2.	3.	4.	5.	10.
M_l	320	320	320	320	320	320
m	90	94	96	97	97·5	98·5

and the temporary moment M after the eleventh magnetisation :—

I.....	14	20·7	27	34	42·5	52·2	62	71
M....	137	157 5	176	200	226	258	294	317
I.....	60·8	45·5	36·7	27	21·3	15·8	14	—
M....	292·2	254·5	225·6	199	176	155·2	150	—

It follows from these observations that even after an iron bar, by repeated temporary magnetisation, either to the same maximum of temporary magnetism, or by currents which always attain the same maximum of intensity, has attained a permanent condition, the temporary moment corresponding to a given magnetising force is always greater with decreasing forces than with increasing forces.

Here, also, there prevails then a complete analogy to the mechanical behaviour under torsion produced by increasing and decreasing torsional forces.

VII. The gradual accommodation of the molecules upon repeated torsion within certain limits, described in the foregoing pages, as recognised by magnetic behaviour, in which the deflections with the same torsion increase at first, agrees with the result of my former experiments, that the permanent torsions of a wire, upon repeated temporary twistings of the same up to a certain limit, and also in the same way upon repeated action of the same torsional force, increases gradually up to a maximum. This behaviour shows clearly that the molecules in the deformed wire are only carried gradually from the position of equilibrium corresponding to the zero into that which corresponds to the deformation. The same holds good of the action of magnetic forces tending to rotate the molecules. Here, also, as the second Table, Section 6, shows, the permanent moment increases gradually up to a certain maximum, upon repeated temporary magnetisation up to a certain limit.

In the same way, as the above experiments show, an iron bar only attains, after the repeated action of a given magnetising force, the maximum magnetic moment corresponding thereto.

This last-mentioned behaviour has already been observed by Quetelet in repeatedly rubbing steel needles with a magnet, and by Hermann and Scholz upon repeated contact with the pole of a steel magnet, and similarly by Bouty and Fromme upon the repeated introduction of iron bars into magnetising spirals traversed by a constant current.* In this last method, the separate portions of the bars are successively exposed to the magnetising forces of different intensity at the different points of the spiral, and thus the position of the molecules of the bars already taken up at one point may assist the adjustment of the molecules at other points in the subsequent introduction into the spiral, or rubbing, and thus explain the increase of the permanent moments. That this is also the case with an unchanged distribution of the magnetising forces is seen from the above experiments.

VIII. In close connection with these phenomena is the thermo-electric behaviour of stretched wires towards the same unstretched, studied by Cohn,† which is certainly one of the most sensitive modes of detecting changes in structure. Here, also, the thermoelectric forces which correspond to equal tensional forces are different with increasing and with decreasing tension. There could be no doubt that the investigation of the thermoelectric behaviour of wires twisted to and fro would give similar results, and this is confirmed by experiment; as also in the investigation of the same behaviour with iron and steel bars, which are magnetised by increasing and decreasing magnetising force. In so far as the torsion or detorsion affects the electric conductivity of the wires, it must show analogy to the magnetic behaviour. This much may, however, safely be concluded from these investigations, that if the molecules of the bodies are displaced or rotated from their former positions of equilibrium, before as well as after the molecules have accommodated themselves by the repeated action of the force, they will always, to some extent, also retain this displacement or rotation upon gradual alteration of the force.

This is seen in various ways. Thus, for example, if the force influencing the body is reduced to zero, a permanent displacement and rotation remains; again, in order to reduce a permanent torsion or magnetisation to zero, a smaller force is necessary than is required for the production of the same. Further, a body which has accommodated itself by the repeated action of increasing and decreasing forces, and is then again repeatedly exposed to the action of the same forces, shows each time, more or less, the position of the molecules

* Meanwhile a similar arrangement has been described by Stebbins, *Centralbz. f. Opt. u. Mech.* IV. p. 119 (1885); *Beibl.* VII. p. 474 (1883).

* I have formerly obtained a series of results on the magnetisation and demagnetisation of iron and steel bars by the same method. Experiments by the method now employed with constant distribution of the magnetising forces give (qualitatively) the same results.

† Wied. *Ann.* VI. p. 385 (1879).

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corresponding to the greater or smaller force preceding that allowed to act last.

Since it is not possible, in the present condition of our knowledge, to express these phenomena of elasticity in the widest sense of the word by mathematical laws under appropriate theories, further experimental researches on this subject are required, in which the time during which the forces act, and the time which elapses after they cease to act, must be taken into account. A thorough study of the magnetic properties of bodies, from which we can infer, up to a certain point, the rotations of the molecules, seems to be especially suited to this purpose.

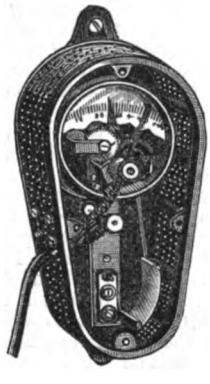
IX. The behaviour of bodies under changes of temperature is quite different from their magnetic and mechanical behaviour.

If a body, whether deformed or magnetised, has been accommodated by repeated heating and cooling, so that the molecules have assumed their final mean position of equilibrium for each single temperature degree, the same mechanical or magnetic condition corresponds to the same temperature, whether with rising or falling temperature. Thus a thermometer, after repeated changes of temperature, gives the same indications at the same temperature, whether with rising or falling temperature, when once the extreme indications have become constant. So also a thermo-element (say of copper and german silver) shows, after accommodation, always the same electromotive force, and a magnet always the same permanent moment at a given temperature, as is shown by direct experiment. The difference is just this, that in mechanical deformation and magnetisation the molecules have been carried over into new more or less stable positions of mechanical equilibrium, by means of mechanical displacements and rotations, out of which they may be directly displaced by fresh mechanical influences; whereas by heating we change only the amplitude of the vibrations of the molecules in all directions above the same position of equilibrium.

A THERMOMETER WITH ELECTRIC ALARM.

The thermometer, figured herewith, is designed for giving indications as to the temperature of silos, grain depositories, piles of coal, or certain fabrics that are apt to burst into flame spontaneously and set fire to factories or ships.

The thermometer used is a metal one, of the Bourdon type, enclosed in a strong cast iron box, provided with a cover of the same nature. This latter is omitted in the figure, so that the



Gerboz's Alarm Thermometer.

internal arrangement may be seen. This box is everywhere perforated, so that the thermometer may be in contact with the surrounding air. The apertures, however, are small enough to prevent the entrance of particles of coal or fragments of seeds, &c.

The apparatus, when placed in a coal bunker or a silo, is connected with the exterior by means of conductors that traverse the surrounding substance, and that serve to indicate, at every moment, that the temperature has or has not reached a dangerous height. As soon as the needle of the thermometer strikes an index, placed at the degree of temperature that it is important to know (50°, for example, showing that there is danger of fire), a bell rings.

We shall now give a few details of construction. As the rotary axis of the needle and that of the index are on the same line, contact between these two pieces takes place at the same point, whatever be the respective angular position of these two parts. Instead of being a simple rod, making one piece with the manœuvering button, the index is composed of a barrel that forms one piece with the button, and upon which is mounted (1) the index needle properly so called, (2) a spring for holding the index in a constant position with respect to the barrel, and (3) a toothed pinion. This latter gears with a cog-wheel upon the same axis with the polarised armature of an electro-magnet. This armature moves in a plane at right angles with the axis of the bobbins of the electro, and as near as possible to the extremity of the core.

The electric communications are established, and the two proposed controls are made as follows:—The cable consists of three conductors. One of these runs from the negative pole of the battery to the thermometer needle and one of the wires of the electro. Another runs from the index to the alarm bell, and from thence to the positive pole of the pile. The third runs from the positive pole of the pile to a galvanometer, then to a button or interrupter, and from thence to the second wire of the electro.

When a contact has been established by the button, the current, on traversing the galvanometer and causing it to deflect, indicates that the two wires and the electro-magnet are in proper order. When the current traverses the electro it polarises the cores, and causes the armature, and consequently the movable index, to revolve around the barrel and under the action of the armature; the index thus tends to move from the maximum point towards the needle, and with it to establish a contact that rings the alarm bell.

When the current is broken by the button or interrupter, the armature, as the current no longer traverses the electro, returns along with the maximum needle to its position of rest under the action of the spring mounted upon the axis of the index.

Were the maximum index made to bear against a metallic rack, forming an electric interrupter in a special circuit comprising an electric counter, we might count the number of contacts between the maximum point and the needle, and thereby ascertain the latter's position.

It will be seen from what precedes that the apparatus may be submitted to a permanent control that permits of making sure that it is ready to operate regularly. Such control is of prime importance, since this thermometer is designed to be used in accessible places (coal bunkers, silos, and so forth), the dampness of which might interfere with the contacts being kept in a proper condition. Besides, the motions of a ship on the sea might cause a breakage of the cable, notwithstanding that it is covered with steel. These two things cannot occur without attracting attention.—*La Nature.*

LEGAL INTELLIGENCE.

Libel on Mr. Cyrus W. Field.

On Monday an action brought by Mr. Cyrus W. Field against Mr. James Gordon Bennett, of the *New York Herald*, in which judgment had been allowed to go by default, came before the Middlesex Sheriff's Court, in Red Lion-square, in order that damages might be assessed for two libels on the plaintiff published in the defendant's newspaper. The case was heard before Mr. Under Sheriff Burchell and a special jury. There was no appearance on behalf of the defendant.

Mr. POLLARD, counsel for the plaintiff, said his client's name was well known on both sides of the Atlantic as the pioneer of Atlantic telegraphy. To his enterprise the public owed the construction of a cable which was carried out at a vast expenditure of his own money and that of his friends. The speculation ultimately resulted in the formation of the Anglo-American Cable Company, of which Mr. Cyrus Field had all along been a director, and had represented its interests solely and successfully in New York. Mr. Field was proprietor of the *New York Mail* and *Express*, and was one of the members of the American Associated Press, which was a body consisting of the seven leading newspaper proprietors in the United States. The defendant was also a member of that association, but later on he was instrumental in bringing about the laying of the Mackay-Bennett cable in opposition to those already existing. This latter company had offices in Cornhill for the collection and transmission of news, and on the 4th of February, 1885, the first libel complained of was sent through that medium as follows:—"London, February 4th, 1885.—Mr. William Abbott, broker and operator, Token-house-yard, supported by many stockholders of the Anglo-American Cable Company, announces that at the Friday meeting of the directors of the company he will introduce a resolution to expel Mr. Cyrus W. Field from the directorship, on the ground that he is unworthy of any position of confidence and trust." This telegram appeared in the *New York Herald* of the 5th of February. There never was such a resolution proposed and there never was any intention to do so. It was, therefore, not only libellous, but utterly untrue in fact. There was a second libel sent on the 12th of the same month, and consisted of an extract from *Truth*, aggravated by a leading article calling attention to it. The telegram was in these terms:—"At a meeting of the company (meaning the Anglo-American Cable Company) held last week, Mr. William Abbott moved that Mr. Cyrus W. Field should not be re-elected. This worthy philan-

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thropist, it would appear, was concerned with Jay Gould in the issue of Wabash preference stock, on which sham dividends were paid until the British public had been induced to buy it, when it fell from 92, the issue price, to about 12. According to American newspapers, Mr. Cyrus Field made by this operation about one million sterling. In these circumstances Mr. Abbott was right in opposing the re-election of this gentleman." For these libels the plaintiff now claimed £10,000 damages. Subsequently Mr. Abbott apologised handsomely and *Truth* also. The *Financial News*, which had copied the telegram, likewise apologised, and the fact of these copies having appeared was telegraphed by the American Associated Press and was inserted in other American papers, but not in the *New York Herald*, showing that the defendant, relying on his own wealth, was regardless of the injury he had done to a fellow journalist. This was clearly a case in which nothing except exemplary damages would bring Mr. Bennett to a sense of his wrong-doing, or compensate Mr. Field for the injury he had sustained.

Mr. Cyrus W. Field, the plaintiff, was called and bore out the opening statement of his counsel. He stated that he was a special partner in the firm of Field, Lindley, and Co., the largest shippers of grain from America to Europe, and having agencies in London, Liverpool, Glasgow, Bristol, and other British and Continental ports. He was besides director of ten large corporations, seven of which were in America and three in London. For some years past he had spent more than half his time in England, where he had a great many friends. There was not a shadow of foundation for either of the libels, and they were calculated to do him immense injury.

A juror: Have you taken any action in America?

Mr. Field: Not yet; I am going to take other action by-and-bye. The libel was originated here.

Mr. POLLARD: The point is that the defendant sent over false intelligence by his own cable, which he neglected to contradict, and for that we seek redress.

Mr. James Maclean, London agent of the American Associated Press, produced the flimsies of three messages transmitted by him contradicting the libellous publications in the *New York Herald*.

After deliberating for an hour and a quarter, the jury returned into court and inquired whether they were to take into account the loss the plaintiff might have sustained in America.

The UNDER SHERIFF: To that I must reply, No.

Mr. POLLARD: I think the jury have a perfect right to take it into consideration, because the libel could not have been published in America if it had not been sent over from the defendant's offices in Cornhill, where it was actually conceived.

The jury again retired, and after an absence of 15 minutes, found a verdict for the plaintiff—damages, £5,000.

COMPANIES' MEETINGS & REPORTS.

The Globe Telegraph and Trust Company (Limited).

The thirteenth ordinary general meeting of the Globe Telegraph and Trust Company (Limited) was held on the 29th inst., at Winchester House, 50, Old Broad-street, E.C., under the presidency of John Pender, Esq.

The SECRETARY (Mr. William Payton) read the notice convening the meeting and the minutes of the last meeting.

The CHAIRMAN: Gentlemen, the resolution I have to move is as follows:—"That the report and accounts for the year ended the 18th July, 1886, submitted to this meeting, be and they are hereby received and adopted, and that dividends be now declared, payable on and after this day, as follows, viz., 3s. per share on the preference shares, making, with previous quarterly payments, a total dividend for the year of 6 per cent. on the preference shares, less income-tax, and of 2s. 9d. per share net on the ordinary shares, making with the previous distributions a total payment for the same period of £3. 12s. 6d. per cent. per annum on the ordinary shares."

Sir DANIEL GOOCH, Bart., seconded the motion.

The CHAIRMAN: Before asking you to approve of that resolution I will make a few remarks on the report, and also give you some information as to the cause of the slightly reduced dividend to-day, and our prospects for the future. Since 1874, when we paid a dividend of 5½ per cent. on the ordinary shares, up to 1885, when we paid 4½ per cent., our dividend has never fallen below 4 per cent., except in the year 1877, when we paid a similar dividend to that which we recommend to-day, viz., £3. 12s. 6d. per cent. per annum on the ordinary shares. The cause of this diminution of dividend is the same to-day as it was then in 1877. It has resulted from the reduction of the tariff for messages across the Atlantic. The rate then was 1s. per word, and to-day it is at 6d. for the associated Atlantic companies. Our average dividend for the thirteen years of our existence has been £4. 8s. 8d. per cent. Of course, our six per cent. preference dividend has been constantly paid, and if we take the two dividends in combination—that is, the six per cent. and the average of £4. 8s. 8d. per cent.—we shall find that we have paid on the combined shares during the past thirteen years a dividend of £5. 4s. 4d., or about 5¼ per cent. Unfortunately for us the dividend from the Atlantic traffic has been a descending one. In 1883 the Anglo and Direct Companies paid us £46,300, in 1884 they paid us £44,800, and in 1885 they paid us £38,500. This year we have only received from the Anglo-American Company £14 000, and from the Direct Company £6,000, say together £20,000, which shows a loss of income, as compared with last year, of £18,500, and this is equal to about 1 per cent. on our ordinary shares. We have therefore only to look at the decrease in the revenue which we receive from our Atlantic holding to find that the results of the competition have been to diminish our dividend on our ordinary shares. Gentleman, that is the dark side of the question at the present moment, the low rates ruling in the Atlantic; but even that dark side has also a bright one. We find that there has been a very large increase in the traffic at these low rates. I might mention that in three months there has been an increase of something like 110 to 118 per cent. We believe that the low rate will develop traffic to such an extent that it may probably 12 months hence enable us to receive, if not the full amount, probably nearly what we have been receiving at the higher rate. I do not mean to say that the sixpenny rate is to be the permanent rate, but this I do say—that the associated companies have resolved to give that rate such a trial as will enable them to judge whether it is to be a paying rate or not. That rests with the telegraphing public. They have now got a rate which cannot be lowered, and if the telegraphing public respond, as we hope they will, I believe that in future the rate for Atlantic telegraphing will be lower than has hitherto prevailed—probably something like the rate which exists to-day. With respect to the other companies, which, as you are aware, form a large part of the capital of the Globe Company, I will first allude to the Eastern and the Eastern Extension Companies. We are also trying in those companies what reduced rates will do as regards increasing the traffic. We have just made a new departure, arising from the Berlin Conference. We have made a new departure from the 1st of July. We have reduced the rates. It takes some time before reduced rates begin to tell, but we hope before long that we may find in the increased traffic some compensation for the reductions which we have made. Altogether, the Eastern and the Eastern Extension system is as hopeful as at any time since the formation of these companies. The German Union Company is suffering to a small extent from the reduced Atlantic rate, and the German-Norwegian Company also. These companies, however, are giving us fair dividends. The Indo-European Company is giving us a very satisfactory dividend. In short, the dividends from the other companies named compensate to some extent for the reduction on the Atlantic companies. That is the great advantage of the Globe Company—that it enables you to get a dividend. Probably had you been in the Anglo-American Company you would be getting no dividend at all at the present time. The future of telegraphy I need not dwell upon, as I have done so so frequently. This, however, I may say—that whether it is in mercantile life or in political life, those who begin to use telegraphy cannot give it up. It has a natural growth. If the country prospers telegraphy must prosper, and therefore, looking at the future, it has all these elements of progress and prosperity in it. I think I have now said all that I have to say at the present time. I would repeat that the Atlantic companies are going to give a fair chance to the low rates now ruling, and that the Eastern and Eastern Extension Companies have laid the foundation of increased traffic by lowering the rates. I hope the result will be that we shall have such an increase of traffic as will enable us, at a very early period, to return to the dividends which we have been paying in the Globe Company heretofore. I now move this resolution, which has been seconded by Sir Daniel Gooch. If any gentleman desires to make any remarks or to ask any question, I shall be very pleased to answer him.

Mr. JOHN NEWTON said he was sorry that he could not allow the accounts to pass without making his usual objection as regarded the deduction of income-tax. A very important principle was involved in that reduction. He did not know how it might affect him in the future, but it concerned him at present so little as regarded this Company that he contented himself with recording his objection. He contended that they had no right to take from him a sum of money as income-tax, and pay the tax to any one else, except to the Government. They did not pay the income-tax at all, and could not deduct it from their shareholders. He would like to ask whether the auditors had seen a voucher for the payment of income-tax to the Government. He knew that they had counsel's opinion on the subject, but he could also produce counsel's opinion to show that they were acting illegally in making a deduction for income-tax. The calling of the meeting on the same day as that fixed for the meeting of the Anglo-American Company was an inconvenience to the shareholders, and he considered that the Directors ought to have sacrificed their own convenience in this matter. They had arrived now at a juncture in telegraphy when Directors must listen to what shareholders had to say. The first declaration in the Articles of Association was as follows:—"That which is at present contemplated as the principal object for which the Company is formed is the acquisition and amalgamation in one company of the principal lines of submarine telegraph and the land lines used to connect therewith. It is proposed in the first instance to acquire these shares and other securities of the companies owning them, issuing the shares of this Company in exchange for them, or to raise funds for the purpose of paying for them, and, as opportunity offers, acquiring and absorbing the businesses and property of the companies themselves." He had the authority of two gentlemen sitting behind the table, in a printed paper issued by them some time since, for saying that it was for shareholders to tell the Directors they wished that principle carried out. If they had carried out that principle they would not have had the trouble in the Atlantic at the present moment, nor would the Atlantic telegraph shareholders be now without a dividend, nor would they have seen the competing lines that had been started—lines started for no other purpose than for five or six gentlemen engaged in commerce to oppose them and take splendid positions as Directors.

The CHAIRMAN: That is a very pretty idea of Mr. Newton's. I always listen with a great deal of attention and respect to anything he says. But would he just show us how we could have prevented the Commercial Company from coming into the field—business men, men of great experience, who, had they looked into the affairs of the existing companies, would

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have been prevented, I think, from putting such an enormous sum of money as they have put into the bottom of the sea. There were strong representations made to them, but they treated those representations as coming from interested parties trying to dissuade them from going into a very good thing. We had no influence to prevent them. They came in, however, and they are now reaping the harvest in getting probably a lower dividend than we ourselves are getting to-day. As long as you are dealing with men who put aside all ideas of political economy and the question of profit, resolved to spend their money, no combination of men will prevent them from doing so. That has been the case with the Commercial Company. As to the income-tax, Mr. Newton has been consistently in opposition as regards that matter for some considerable time. But I am obliged to say this, that we are bound to respect the law, and bound to go to the very best authorities to read that law for us. That law has been read to us, and it is in accordance with that reading that we are now dealing with this matter. We have taken the very highest authority in the law, and we are obliged to respect their decision, notwithstanding that you hold other views.

Mr. NEWTON: Would you give us your authority?

The SOLICITOR (Mr. Burt): Sir Richard Webster and Mr. John Rigby. These are two of the authorities that I remember, but I do not know that there were not others. I was not prepared for the question.

The CHAIRMAN: There were differences of opinion at the Board with regard to that question, but it has been thoroughly threshed out, and we are acting in accordance with the highest legal opinion in the way in which we have dealt with this matter. I think Mr. Newton has good reason to complain that this meeting and that of the Anglo-American Company should be held on the same day.

The SOLICITOR: I believe they were both fixed on the same day.

The CHAIRMAN said it should certainly not occur again. He then put the resolution, and it was carried unanimously.

On the motion of Sir DANIEL GOOCH, seconded by the Marquis of TWEEDDALE, Mr. John Pender was re-elected to his seat at the Board.

The CHAIRMAN: I am very much obliged to you for the honour you have done me in again re-electing me. This is one of the hobbies of my life. I am particularly pleased to have the confidence and support of the shareholders in conducting this business.

On the motion of the Marquis of TWEEDDALE, seconded by the CHAIRMAN, Sir James Anderson was re elected a Director.

Sir JAMES having acknowledged his re-election,

Mr. NEWTON proposed the re-election for the ensuing year of Mr. J. G. Griffiths, F.C.A., and of Mr. Wm. Griffith, B A., as auditors. He said that, notwithstanding what the Chairman had observed, he would ask the auditors to search for the voucher for the payment of income-tax. He ventured to say they would not find it, and also that, in spite of the opinion which the Chairman had mentioned, the proceeding was illegal.

Mr. FULLER seconded the motion, which was carried unanimously.

Mr. GRIFFITH, having returned thanks, said that he had considered the question of income-tax, and there was unfortunately no doubt that that had been paid; but he rather agreed with Mr. Newton as to the legal opinion. That, however, was not a question for the auditors. They had looked at the securities, which were all safe, and they had examined the books, which were all well kept, and he thought that they could well certify not only what they had certified, but also that the Company was in a sound position as far as the books and the securities showed. Continuing, he proposed a vote of thanks to the Chairman, whose name and reputation he said extended all over the land. Mr. Pender was a gentleman well known in parliamentary, commercial, and still more in telegraph circles, and he thought they were fortunate in having him as their head. It was Mr. Pender who had conceived the idea of the Company, who had founded it, and under whom for so many years it had been successful. He hoped that Mr. Pender's life would be long spared, and that the success of the Company would continue to be greater, and that their dividends would grow.

The motion having been carried,

The CHAIRMAN said: I have very great pleasure in thanking you on behalf of my colleagues and myself. It gives us great pleasure to meet you again, and it would give us greater pleasure still if we received larger returns, so that we might pay you a more satisfactory dividend than you are getting to-day. Your interests will be carefully watched in the low rates that are now being experimentally tried, and I hope that when we meet you a year hence we shall be able to give you a better account than we have given you to-day.

The Anglo-American Telegraph Company.

The ordinary general half-yearly meeting of the proprietors of this Company was held yesterday (Thursday) at the Cannon-street Hotel, Viscount Monck (Chairman of the Company) presiding.

The SECRETARY (Mr. T. H. Wells) read the notice convening the meeting, and the report was taken as read.

The CHAIRMAN: It is now my duty to move the adoption of the report. In doing so I shall not take up your time with any comparison of figures, because from the circumstances of the case anything of that kind would be completely illusory. The rate of tariff has been changed since the last meeting, or since this time last year, and it would therefore be absurd to compare the figures. I may say, however, in passing, that if you compare the expenditure of the two half years you will find that economy has been studied as far as possible consistent with the maintenance of the efficiency of the service. I have also to state to you, as you will see in the report, that your plant is all in good condition and working order, and that you are carrying a very large, though I am sorry to say at present a not very remunerative, traffic. Well, gentlemen, the truth is, the question we have really to consider to-day, which dominates the whole situation and appears in almost every line of this report, is the mode in which we must meet the competition in which we are engaged. Nevertheless, before I come to that subject, there are one or two topics to which I would wish to draw your attention. You will remember, as you have been reminded by the minutes which have just been read, that at the last meeting we entered into an arrangement for suspending contributing to the renewal fund from revenue as soon as that fund should have reached one million sterling. Speaking roughly, at the time that meeting was held we calculated that that state of things would have arrived at the end of the present year. Now, circumstances have considerably changed since that time. Our revenue has diminished, and we shall not be able, in all probability, to put by to renewal fund within the current half-year—the half-year which is just beginning—as much as we should have done if our income had remained the same. Notwithstanding this, we shall be able, I hope, to put by a considerable sum to that fund, and if it will not probably attain to the entire amount of one million by the end of this year, it will come very near to it—it will come so near to it that your Directors are disposed, as at present advised, not to disappoint the hopes of those who took that view of the matter, and they will suspend, if circumstances continue the same, any addition from revenue to the renewal fund at the end of the year 1886 [applause]. Gentlemen, of course I need not say that this proposition is dependent on the same conditions which attached to the original agreement, viz., that we should not meet with any extraordinary disasters in the meantime [hear, hear]. Well, gentlemen, there is another matter which was alluded to at the last meeting. Some gentleman in the room attached to some words that dropped from me a meaning which I never intended them to bear. He imagined that we were going, in case of a war of rates or of competition, to make use of the renewal fund to tide over that opposition. I at the time stated to you my opinion that any use of this fund beyond that for which it was originally intended, viz., the renewing of your plant, would be a gross case of malversation on the part of the Directors. I still adhere to that opinion, and I believe the great body of the shareholders would be disposed to trust the present Board in the matter [applause] At the same time contingencies might arise—we might pass from the stage and others take our place; but I am authorised by the Board to assure you that no expenditure of this fund shall take place, except for the purpose of repairs, without the shareholders being consulted on the subject [applause]. There is yet one other matter. I dare say some of you have noticed the decision in one of the courts of law, that it is not legal for Directors to pay the expense of proxies out of shareholders' money. That has been so decided, and having been so decided your Directors, of course, are bound by the law, as long as that case remains undisturbed. We have therefore come to the conclusion that all expense of proxies, stamps, printing, posting, and so on, shall be paid for by the Directors out of their own individual fees, and that no portion of that expenditure shall any longer be charged to the shareholders. I now come to what is really the great question, and that is the competition in which we are engaged with the Mackay-Bennett cable. We were often denounced as monopolists; but, to be candid wth you, that is an accusation that sits my very lightly on my conscience. I have always held that my first duty to the stockholders of this Company was to obtain for them the best return for their money that could be obtained. If that could be done by securing a monopoly, I see no reason why we should not take that course, and in truth the people who accuse us of being monopolists suggest to us that we should create a natural monopoly by reducing the cost of our work, so as to enormously increase our receipts. Hitherto we had acted on the principle that where combination is possible, competition is not likely to occur. If you cast your eyes back for 20 years, when this Company was first established, and when telegraphic communication across the Atlantic was first brought into existence, you will find that the charge for a message across the Atlantic at that time was £20. Well, no one objected to that at that time. We had never been used to telegraphy, and we were overjoyed to be able to send a message across the Atlantic in a minute or two at any price. However, not long after that occurred, people began to think that those who were carrying the messages at £20 a message must be making rather a good thing of it, and a rival company started up. I am sorry to say I had something to do with that company myself, and we found when we laid our cable that we were not at all mistaken in our speculation, and that it was a very good thing. However, after a very short time, proposals were made to us, and we were amalgamated with the original Anglo-American Company, and for a short time we continued to have a monopoly of the telegraph trade to America. But other people began to think there was something more to be made out of it, and not long after the Direct Cable Company arose. That was treated in the same way, because though we did not amalgamate with it, we had a tariff arrangement, and it came to practically the same thing. That immediately led to the laying of other cables, and I need not pursue this history further, because you are all aware that each one of these arrangements was succeeded by the institution of a new company. A new competition arose, people thought there was something good to be got out of it, and they went in for additional cables. Naturally it has now come to pass that there are cables enough in the Atlantic at the present day to do about ten times the work that they are called upon to transact. When the Mackay-Bennett cable was started we determined to try the effect of fair competition. After a short time we found—and I do not want to complain of the Mackay-Bennett people, because they were perfectly justified if they thought they could get a good thing in getting it any way they could—but we found they were giving exceptional advantages to individuals, and that they were completely undermining our *clientele*. Therefore we found that we must come to a tariff that would lead to a regular competition and hostile

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proceeding on both sides. We put down, therefore, our tariff to 6d. a word, as you are aware. Well, the Mackay-Bennett Company continued to charge 1s., and, wonderful to relate, I believe they are getting people to pay 1s. for what they can get for 6d. at this moment. I do not believe that such a thing will last. I believe they adopted a low tariff, supposing that we had merely adopted a temporary measure which would not be persevered in. We have determined now to try an extensive and persistent low tariff, with the view of stimulating the increase of traffic, and seeing if we cannot make a good living on a basis that cannot be upset [applause]. We have some encouragement, as you will see by the report, in that policy, for within a very short time of the institution of the 6d. a word tariff our traffic more than doubled—the report states it is 110 per cent. increase. Well, we determined to try whether that increase cannot be made greater, and whether we cannot bring the traffic under a low tariff to such a point as will enable us to make a dividend for you in a way that will not encourage future competition, and will be permanently beneficial to your Company. Gentlemen, that is the policy which your Directors have at the present moment adopted, and which they are thoroughly determined to persevere in until they see whether it can be worked with advantage to you. I will not conceal from you that it is a policy which will draw largely on your forbearance, and it cannot be carried into effect without your giving an extended support to your Directors. Therefore I hope, in the interests of this Company and of the stockholders themselves, that you will join as one man with the Directors in instituting and maintaining this policy, and in giving it a fair, extensive, and complete trial. I do not think it is necessary for me to trouble you with any other matter. I have described as succinctly and as clearly as I could what our intention is, and I shall now, therefore, move "That the report of the Directors and accompanying statement of accounts to the 30th June, 1886, submitted to this meeting, be, and the same are hereby, received and adopted."

The Marquis of TWEEDDALE seconded the resolution.

Mr. THOMAS SMITH said that, as the representative of nearly a million of stock, he supported the adoption of the report. It was encouraging under the circumstances to find that the traffic at the reduced rate of 6d. should have more than doubled in the first month after its introduction. The result was not so unsatisfactory also if they thought of the continued depression of trade and the unfair competition they had to contend with. At the last meeting the Chairman had indicated that an agreement for an amicable arrangement of traffic with the Bennett-Mackay Company might be arrived at upon equitable terms. The Bennett-Mackay Company, however, had been most outrageous in their claims of 40 per cent. of the whole traffic and other preposterous terms based on their traffic, obtained by rebates and otherwise. Of course such terms could not be entertained, and the Bennett-Mackay Company declared war upon this Company by immediately reducing the rate from 1s. 8d. to 1s. per word. The Board of the Anglo-American then wisely reduced their charge to 6d., thus checkmating the game of rebates, which would have been carried on had the rate been made a shilling one. In the case of this Company the war was one of defence, and their rights of twenty years had been invaded without just cause. The policy of the Board had hitherto been one of conciliation to all comers, but the time had now arrived when company promoters should be taught that there was no room for fresh cable schemes across the Atlantic, and that no further concession would be made. If the Bennett-Mackay Company reduced their charge to 6d., this Company must immediately put down the rate to 3d., or lower still if necessary. The Company is in a sound financial position, without mortgage or debenture bonds of any kind to provide for, and with a renewal fund sufficient to meet all contingencies, while all the cables, with one small exception, were in good working order. The other Company, he believed, had not yet been able to place their stock, and as the public would not have them these millionaires had been obliged to borrow a large sum of money at 6 per cent. in debenture bonds, he believed. The shareholders of the Anglo-American Company must, therefore, exercise a little patience. He had no doubt the present contest must soon end. Their action at present was one of self-defence, but if the Directors now allowed their opponents to escape without making such an example of them as would deter all promoters for the next twenty years interfering with their just rights, they were not the friends of the shareholders. He only regretted the Board had not adopted this policy much earlier [applause].

Mr. GRIFFITHS said that the last speaker had come forward as representative of an association called the Anglo-American Shareholders' Association. He (the speaker) happened to be a member of that association, but he differed altogether from the policy advocated by the last speaker. He would therefore protest as to Mr. Smith appearing as the advocate of the association. It had been said that they possessed a renewal fund, which was shortly to cease; but what was the advantage of the renewal fund when they already had more cables than was sufficient to transmit ten times the present amount of business? Why should not this renewal fund, therefore, be utilised for the purpose of equalising dividends? The proprietors had it in their power to do this. They were told that the traffic had increased by 110 per cent., but they were not told at the same time that during that particular period there was a great political crisis in this country, and that the press messages arising from that cause would increase the business enormously. The Directors in their report stated that they only desired a reasonable return upon the capital subscribed, and to prevent further wasteful competition; but the Board should not, as business men, be satisfied with it, as it was their duty to obtain the highest dividend they could for their shareholders. It was said that sooner or later a low tariff would be necessary; but the past showed that the Company had wasted its resources and brought no return into the pockets of the shareholders. He should have liked if the Board in their report had expressed a little more sympathy with the sufferings of those who had lost their dividends. The shareholders of the French Company in Paris had said that they would not permit their funds to be squandered uselessly, and for no purpose.

Sir CHARLES SWINBURNE asked if the Board intended to add the interest of the reserve to increase that fund after this year?

The CHAIRMAN: Yes.

Mr. HERON asked why so large a sum as £50,000 should be set aside to the reserve at one time.

Mr. JACKSON repudiated the idea that Mr. Griffiths represented the feelings of the Anglo-American Shareholders' Association, as he had not attended the sittings of that body. He was glad to find that the management of the Company was waking up to the duty of studying the convenience of their customers. This Company had been a pioneer company, and pioneers too often sowed for others to reap; but they had the future in their hands, and a traffic at a low tariff would employ all the cables. Some of them, too, would be surprised to learn that the average dividend for the last ten years had been £3. 10s. per cent.

Mr. NEWTON thought that Mr. Griffiths had a perfect right to give his opinion as a member of the Shareholders' Association. Mr. Jackson had said that the average dividend for the last ten years was £3. 10s. per cent., but those shareholders who had joined the Globe Submarine Trust received not that amount, but 5¼ per cent. from that day to this. Knowing that this Company was not prepared for the present fight, he had sold his stocks at 60. By the manner in which the renewal fund was dealt with they were placed before their competitors like an army without weapons.

Mr. STOCKDALE endorsed the policy of the Board in meeting the competition, and in adopting a 6d. tariff, and believed that they might justly call upon the shareholders for a little forbearance.

Mr. CHESTER said he was accustomed to strange changes, but the policy the Chairman had that day advocated was the strangest change he had ever seen. For years they had been told from the Chair that a 1s. or 2s. rate was not a paying rate, and that any step in the direction of reducing the tariff was entirely out of the question. The policy of monopoly and of increased rates had led to the introduction of fresh cables, while the present policy was attended with no profit. The interests in this Company which ought to be considered were those of the ordinary and preferred shareholders, for the deferred shareholders had accepted their position.

The CHAIRMAN: Gentlemen, I do not think there remains very much to say in reply to what has been said. The gentleman who has just sat down has put words into my mouth. I do not like to put my memory against his, but certainly, as far as my memory carries me, I do not remember that. I have often said that we have tried different rates of tariff, and that up to this time we have never found the lowest rate we tried so sufficiently remunerative as to go on. But we have never before tried for any length of time so low a tariff as at present, and the Board were astonished, I am bound to say, at the extraordinary rise which took place in the traffic of the Company immediately on the institution of so low a tariff as sixpence. The gentleman has sneered a great deal at the past policy of the Board, but we acted according to the best of our lights. We do not claim any character of infallibility, and if we find we have been wrong we are ready at any time to retrace our steps [applause]. There was one observation made by Sir John Swinburne, which, though I have often explained the matter in this room, I should like to explain again. He says I stated, and he states truly, that I said that we have the capacity of carriage of traffic across the Atlantic very far beyond the traffic that we have to carry. Therefore, he says, why build up a reserve or renewal fund for the purpose of renewing cables when you have too many?

The CHAIRMAN went on to say that if all the cables in the Atlantic belonged to the Company it would be a very good argument, but they had only four out of eight, and the retention of their portion of the income depended on their keeping up those four cables [hear, hear.]. If one of these failed their portion of the income would be immediately reduced, and that was the reason why, notwithstanding the fact that they had a greater power than was absolutely requisite for the traffic, they were bound to keep up the number. A question was asked as to adding the interest of the renewal fund to that fund. That action was based on an arrangement come to in that room with the shareholders generally at the last meeting (hear, hear), and it would not be acting rightly if this arrangement was not duly carried out. The placing of the £50,000 to the renewal fund was also part of the arrangement entered into with the shareholders at the last meeting.

The resolution was then put and carried.

On the motion of Mr. SMITH a vote of thanks was passed to the Chairman, and the meeting separated.

The Direct United States Cable Company (Limited).

The eighteenth ordinary general meeting of this Company was held at Winchester House, 50, Old Broad-street, E.C., on Friday, the 23rd July, 1886, under the presidency of John Pender, Esq.

The SECRETARY and TRAFFIC MANAGER (Mr. J. W. Fuller) read the notice convening the meeting.

The CHAIRMAN: Gentlemen, before putting the resolution asking you to approve of the report and accounts, which have been in your hands for some days, and which I presume you will take as read, I will, as usual, give you some details. The revenue for the half-year to 30th June, after deducting out payments, amounted to £28,445: and the working and other expenses, including income-tax (but exclusive of cost of repairs), absorb £15,867, leaving a balance of £12,578 as the net profit of the half-year, making, with £5,967, brought from the previous half-year, a total of £18,545, which has been appropriated as follows:—

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Interim dividend of 3s. per share to 31st March, £9,106. 10s.; proposed final dividend of 2s. per share to 30th June, £6,071; transferred to reserve fund, £316. 13s. 2d., leaving a balance to be carried forward of £3,050. 19s. 3d., making a total of £18,545. 2s. 5d. The revenue shows a reduction of £7,661, as compared with the June half of last year, owing entirely to the introduction of the sixpenny tariff on 5th May last. As stated in the Directors' report, the result of the reduction, so far, has been to more than double the volume of traffic, without developing a remunerative revenue. The working expenditure in London and at stations shows a reduction at the rate of £600 per annum, notwithstanding the expenses of advertising and otherwise making known the reduction of rates, and in spite of the cost of working additional joint stations at Glasgow, Bristol, and Havre, which were not in operation prior to June, 1885. The result of the expenditure, on the whole, shows a reduction of £1,340 in favour of the present half year. The important economies effected by the Company from year to year since its reconstruction in 1877 have now brought the normal working expenditure down to the lowest point consistent with the efficient working and maintenance of the Company's system. No further reductions can, therefore, reasonably be looked for; but every possible economy will continue to be exercised. The reserve fund, after being credited with interest on investments and profit on sale of security, and being debited with cost of repairs, now amounts to £325,000. The present market value of the Company's investments continues considerably higher than the amount of their cost to the Company.

Now, gentlemen, these are some of the details connected with the working of the Company during the past half-year. For the last 18 months when I have met you at these half-yearly meetings I have told you that there was looming in the distance a competition, and a very active competition it was likely to be, if we really began to fight. My colleagues and myself earnestly desired to prevent that fight, and I believe the associated companies also were equally earnest in that desire. We did everything we possibly could consistently with our duty to our shareholders and the position which we hold as the great pioneers of Atlantic telegraphy. The result has been that no arrangement could be come to whereby such a rate could be agreed upon that would be fair to the public, and give the shareholders a moderate dividend. As you know, you have never had a very excessive dividend, because, what with the competition and what with cables springing up right and left, and with the coding system at work at the same time, we have never been able to get at the point in dividend which such an enterprise as Atlantic telegraphy was entitled to. If we have not been able to make an arrangement that would give a satisfactory dividend, we have endeavoured to do the next best thing—to utilise our cables to such an extent, at a low price, as would test the telegraphing public and throw the responsibility of low rates on them. The result has been, gentlemen, that in reducing the tariff to 6d. we have more than doubled the number of messages passing over our system. In fact, I believe to-day that it may be said to be 110 if not 118 per cent. above the previous traffic. That, gentlemen, is still insufficient to give the dividend which we consider that you are entitled to, but nevertheless we think that having begun this 6d. rate, and seeing such an enormous development in so short a space of time—for we have not been competing for more than three months—I think we may expect, having done that in three months, to do a great deal more in twelve months. While we were anxious to avert this lowering of the dividend, I think we have struck a vein in submarine telegraphy which we are determined to see to what extent we can work; therefore, we have made up our minds to do that, and I hope it will meet with the approval of the shareholders, because our shareholders during the last eighteen months have encouraged us to go in to this fight, if a fight was necessary. It is, however, a fight which I hope will result in an enormous increase of our traffic, and I hope in the permanent establishment of low rates. At all events, as business men, we have determined to give it a fair and proper trial, and we hope we shall meet with the support of the telegraphing public, and that our shareholders will also be patient, and contented during the next twelve months and approve the very modest dividend which we are going to declare to-day; and if we have the support of our shareholders depend upon it there is a considerable future in the policy which we are advocating. My reasons for saying that are these: We have eight cables. I put the Commercial cables out of the question altogether. If the matter had been seriously and well considered by the Commercial Company, their cables ought not to have been in the Atlantic to-day. There was no call for them; there was no necessity for them; and every cable that is put down in the Atlantic makes it more difficult to lower the rate, because you are putting a larger amount of money at the bottom of the sea, and, consequently, you are less able to give a return upon that additional capital. Telegraphy does not grow so as to give, even at very reduced rates, the return which these additional cables would require in the way of increased traffic. But as I have said, we have eight cables, and these eight cables, which are capable of carrying over forty million words per annum, are at the present moment carrying only about fifteen million words. That shows that there is an enormous margin of cable power, and we think it better to use that cable power, at all events for a time, in giving an opportunity to the telegraphing public to double, treble, and I hope quadruple the amount of the present traffic. If that is the case I think it will be unnecessary to return to rates much higher than those charged at the present moment. I may mention another fact—that I doubt if we should have been in a very great hurry to reduce the rate from 1s. 8d. had it not been that the competition was carried on on a principle which we could not approve. In fact, our traffic was being taken away from us under pledges and promises that we have never been any party to, ourselves, and consequently when we saw that practice going on to an extent that was interfering materially with our traffic, we thought the time had come when we must put our feet down and take a firm stand. That we have done, and, as I say, I hope with the prospect of considerable success. I may mention that while we have reduced the rate to 6d., the Commercial Company have only reduced theirs to 1s. We learn that a very large amount of the support they are receiving comes from America—that their principal traffic from this side is influenced by the same public. Now, I know something of the American public, and of American mercantile life, and I do not know of any community who appreciate more accurately the value of a dollar than the American public do. They have gone on for a short time paying this 1s. on the promise that 6d. was to be returned to them if they ever return to a tariff exceeding 1s. 8d. I think we may give up the idea of 1s. 8d., and I think that when the American people find out that they can get their work done—I will not say better, but as well—with our eight cables, the American people are not likely to pay 1s. when they can get the work done for 6d. I have made a remark that the Commercial Company came into a field of which they had very little knowledge, but of which their experience by now must have satisfied them that they would have done better to leave their money in other investments than put it in telegraph competition; but I think before this competition is at an end they will find that the representations made to them—as I believe they were—that enormous dividends were to accrue from these cables were all fallacious—that probably those who promoted them were the only parties who got any benefit out of these new cables. I hope, at all events, it will be a lesson to those who enter on telegraphy in the future that they should understand the business thoroughly, and its conduct from all points of view before they put such large sums of money at the bottom of the sea as these gentlemen have. I may say that the competition, while it has been going on, has been conducted in such a spirit that there is no reason to complain of. I see that our customers are coming back again, that we are doing our work in a way that is commanding the confidence and respect of the public generally, and as we have made up our mind to give this 6d. rate a fair trial I think we shall very soon find that the bulk of the Atlantic telegraphy is passing over our system. Now, gentlemen, with these remarks I beg to move the following resolution:—

"That the report of the Directors dated 9th July, 1886, together with the statement of accounts to 30th June, 1886, annexed thereto, be and the same are hereby received and adopted, and that a final dividend be now declared of 2s. per share, free of income-tax, making, with the interim dividends already paid, a total dividend of 2¾ per cent. for the year ending 30th June, 1886."

Mr. WILLIAM FORD: I beg to second the resolution.

The CHAIRMAN having invited discussion,

Mr. JACKSON said he was glad that the Company had decided on cheap rates. In the past the old companies had been held *in terrorem* over the heads of the public, and it had been said of them that when they had succeeded, by cutting rates, in crushing the opposition brought against them, they would raise the rate to 2s 6d., or 3s., or higher, and he believed that was at the bottom of the competition of which the chairman had complained. He thought, under the circumstances, that the directors had been justified in entering on a war of rates. He did not think that the dividend proposed ought to be paid, and that the Directors should have done what the Anglo-American Company had done, viz, the amount proposed to be distributed should have been put to the reserve fund. If, as he trusted, the shareholders would support the united Board—and especially the Anglo-American Board—in the present struggle the Company would be able to assume a position which they had never done before. They would be acting on commercial principles in developing traffic. He trusted that the shareholders would support the Directors, even to the extent, if it were necessary, of going without a dividend for a short time [no, no]. He did not say that it would be necessary, but they had to compete with a company that was very keen.

Mr. JOHN NEWTON congratulated the meeting on the bellicose tone of Mr. Jackson, of whose remarks as to the way in which the Directors were meeting the competition he heartily approved. He thought they should sympathise with the shareholders of the Anglo-American Company in having to go without a dividend, but he did not think that they in the Direct Company would have to do so. The constitution of the two companies was quite different. The Anglo-American Company could not use its reserve fund, but the Direct Company could do so in a proper way, and they could rely upon it for the maintenance of their income. The Direct Company could pay a dividend in the face of any competition so long as it had a substantial reserve fund, which was the backbone of the company. It was that fact which maintained the value of their shares.

Mr. W. GRIFFITH said he did not wish at the present critical period of their history to criticise in a harsh spirit the policy adopted by the Board; but at the same time the shareholders had to pay for it, and pay very heavily. Their dividends had fallen, and they appeared likely to fall. One reason why he objected to the present warlike policy was that they had to pay heavily for it, and that they had adopted it in the past and had not found it pay. He thought the unclaimed dividends might be utilised for the purposes of the Company, following the example of some other companies.

Mr. E. M. UNDERDOWN: The quotation would be stopped if you did.

Mr. GRIFFITH dissented.

The CHAIRMAN pointed out that the amount at present was only £227. Now I will reply to Mr. Jackson. Probably no question has had more serious consideration by your Board than that of paying a dividend at the present time; but what we felt was that having made up our mind to this low tariff, and having determined to continue it for a very considerable period—at least, for such a period as would thoroughly enable us to judge whether these low rates were going to give us the required amount of traffic to pay moderate dividends—we thought it would only be just and right, not only to the interests of the Company, but to the shareholders, that we should try and give them a small dividend (hear, hear) to encourage them with us to fight this battle; because if you have reluctant shareholders behind you, you never can fight with the same success that you will if you have every share-

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holder heart and hand with you. Therefore we resolved to do this, and thought we might fairly do it. Our Articles of Association entitles us to take from the reserve fund such an amount as the Directors would consider necessary for equalising our dividends. We have, therefore, considered it desirable during the present competition to be generous as well as just to the shareholders, and instead of carrying the net earnings for the past half year, viz., £12,578 to the reserve fund, which we might have done so as to keep up our annual contribution to it, we have paid that amount to the shareholders, and have carried to the reserve fund as usual the full interest earned on that fund. Therefore we have been alike just to the shareholders by giving them a dividend—a dividend making up the rate for the year to 2¾ per cent., being equal on the market quotation to-day to 5½ per cent. Having established for you a very sound reserve fund—I would not say "ample," because that is not the word—an amount of £325,000 ———

Mr. UNDERDOWN: £5. 7s. a share.

The CHAIRMAN (continuing): Having done that we are in a position, for a short time at all events, to suspend adding to the reserve fund preferring to keep our shareholders in good heart, and give them some return while the fight is going on. That is the reason we have been anxious to meet you in this respect, at the same time doing equal justice to the reserve fund. We have placed ourselves in a position that I am quite sure you will be prepared to fight for. I am not going to say for what period; but as long as we are able to show you that we are increasing our traffic enormously, or largely, and have a prospect of being able to give you a dividend in future out of these reduced rates, I think you will encourage us to go on. I believe myself that telegraphy is yet comparatively in its infancy. The development that has taken place is something enormous in this instance. I have been asked the question why we did not get the same result when the rate was 6d. before. I cannot give you a better argument than this—that telegraphy since then has taken such a hold of the public—the commercial, social, and political life of the world, not only in small things, but also in large things—that this rapid development at the low rates is simply from the effect of what I state. Every man must have telegraphy. He cannot do without it. I believe there is scarcely a man in this room who does not use telegraphy many times daily in the course of the year. I have told you that we are strong from our reserve fund. Our associates, the Anglo-American Company, are equally strong in their reserve fund, and if ever there were two companies in a position to work out this problem, we are in that position; and we are determined to do it, and we will place the matter in such a way before the public that they will not be able to cry out for reduced rates if they do not support us. As to the proxies, I may say that we have passed a resolution to-day that our proxies should be paid for by the Directors, but having done that to meet the law, let me answer this gentleman, who says that if people do not come to the meetings they have no right to be represented. We have 1,450 shareholders, and I suppose there are not 100 here. A great number of those shareholders have three, five, seven, or ten shares. Surely their interests are entitled to be protected. If we had no proxies—this occurred the other day in France—people might combine against us, unknown to us, and upset your business. Men who are your enemies, who are antagonistic to your interests, might do this, and before the danger could be averted, the whole thing might be upset. You must have confidence in your Board. I would very much rather that proxies went out and that every man would put a stamp on himself. We do not want to do anything that our shareholders do not thoroughly approve of. It will come to this—that one of these days if I find difficulties arising in anyway I may ask you to pass a resolution to support the Board by authorising the Directors at public meeting to issue proxies. We must not be taken by surprise. We are protecting your interests. We have shown you that we have protected them from the very first of our taking office, and we will continue to do so. If you think that in sending out proxies we are doing an unjust thing or anything to hurt you at your expense, you are making a mistake. We only ask you for your confidence and support by giving us your proxies, and I am pleased to say that we are getting a large number of proxies. However, to be in perfect accord with the law the Directors will pay for these proxies; but I hope that a gentleman such as Mr. Jackson will later, without my saying anything more, propose a resolution, authorising the Directors to pay this expenditure. That would throw the responsibility upon the shareholders, and show that the shareholders had perfect confidence in their Board. He then put the resolution in the usual way, and it was carried. Continuing, he proposed the re-election as a director of Rear-Admiral R. C. Mayne, C.B., M.P.

Mr. UNDERDOWN seconded the motion.

A discussion followed, at the instance of a shareholder, who thought that in the present crisis the Directors' remuneration of £3,000 a year should be reduced to £2,000, or that the number of Directors should be reduced from eight to six, a corresponding diminution being made in the amount of the fees.

Mr. JACKSON and Mr. NEWTON, on the other hand, argued that the proposal was inopportune, and, that it would be unjust at the present time, when more work than usual was thrown on the Directors, to reduce their remuneration.

The CHAIRMAN, in reply, stated that an alteration in the number of the Directors would require an alteration in the Articles of Association. If, however, a resolution to that effect were brought forward at a meeting of the Company, and was approved by the great body of the shareholders, the Board must submit. At present the Directors were acting in accordance with the Articles of Association. He might add that the first act of the present Board on taking office, having after a very hard fight rescued the Company from wreck, was to reduce the remuneration of the Directors from £4,000 to £3,000 a year. Previous to that the Company had been in existence three years, and had not paid the shareholders one penny, the Directors at the same time taking £4,000 a year. In the time of the present Board the fees had been reduced by £1,000, they had built up a very large reserve fund, and until the last year they had paid a dividend of 5 per cent. If any crisis should arise in this Company rendering it necessary for the Directors to make a sacrifice they would be the very first to offer to do so.

The resolution was carried; and a similar result attended the election of Mr. Charles Meara, who was proposed by the CHAIRMAN and seconded by Lord HAWKE.

On the motion of Mr. JACKSON, seconded by Mr. WEAVER, Mr. John George Griffiths and Mr. John Sawyer were re-elected auditors for the ensuing year at a remuneration of £50 each.

Mr. GRIFFTH then proposed a vote of thanks to the Chairman, Directors, Secretary, and staff, whose services he warmly acknowledged.

Mr. JACKSON seconded the motion, which was carried unanimously.

The CHAIRMAN, in reply, said that at the present time a great deal of care and attention were required in watching over the affairs of the Company, and he was pleased to state that the Directors received the very greatest support from the secretary and traffic manager and staff in the conflict that was going on. The remarks which had been made in the course of the discussion had been in a very proper and courteous spirit, and the Directors received them in the same spirit. He would only add that if shareholders desired their business to be well conducted they should pay Directors well and hold them responsible, and then if Directors did not do their business well, shareholders should get quit of them as soon as possible.

The proceedings then terminated.

Edison and Swan United Electric Light Company (Limited).

The annual general meeting of the shareholders in this Company was held at the Cannon-street Hotel on the 27th inst., under the presidency of Mr. James Staats Forbes.

The SECRETARY (Major S. Flood Page) read the notice convening the meeting, and the report of the Directors was taken as read.

The CHAIRMAN, in the course of his remarks in moving the adoption of the report, said: It would be very gratifying to us in a concern of this sort, not yet emerged from trouble, to have a larger attendance of proprietors, but such as the meeting is we shall be very glad indeed to put before it all we have got to say. The report is not as satisfactory as we hoped last year to have been able to present, and yet it is not entirely unsatisfactory upon some other points of view upon which I shall have to enlarge as I go through it. We wound up our meeting last year by wishing on both sides of the table that the prosperity which then for the first time had seemed to have been achieved for the company would continue. Well, it has not continued, but perhaps when we come to the details of the report we shall see there are some reasons, which, although not entirely satisfactory as regards the financial outcrop, still leave us with some grounds for satisfaction upon other points. The whole story is told in the second paragraph, which states that there has been a considerable diminution in the number of lamps sold in the year. The diminution is so considerable that it is the difference between a considerable profit and a very inconsiderable—in fact, quite nominal—profit which is shown by the accounts themselves. We have had a reduction in the year in our sales of lamps of no less than 125,000 compared with the present year. Well, we have tried, of course, to find reasons for that. One principal reason is that in the previous year we were the manufacturers for a great foreign trade. That foreign trade is in the hands of another corporation with which we are allied, and in their discretion—whether it will turn out a wise discretion or not we need not discus here, we shall have to discuss it later on—they, following their undoubted right, thought it more in their interest to manufacture lamps abroad than to take them from us. That accounts for the greater part of that deficiency—74,000 lamps which we sold last year to the Swan Company for their foreign business they have manufactured for themselves this year. Of course that has this effect upon our business with regard to the number of lamps, that the greater the volume of lamps you put out the less is the relative cost of the lamps; I mean to say that the fixed charges of producing a small number—relatively small number—are the same fixed charges as for producing a larger number, and the profit upon those 74,000 lamps realised last year would have been as great this year if we had made them, without any appreciable addition to the fixed charges. Of course, there would have been the charge upon the mere material of the lamp. Well, then, on the home consumption there has been a decrease of 41,000, and I think that must arise from two causes. First of all there has been the infringing. No doubt everybody makes lamps—a great many people rather—and infringers, like other sinners, got bolder by immunity, and we were not in a position until very recently to call those gentlemen to account. Of course you know what patents are, and with regard to yours, at great cost you have established their legal validity. Everybody knows in this country that the law marches very slowly, and the wrongdoers get a great pull, because it takes a long time to get justice. That has been our case, and we have in the interim between our last meeting and now been successful, notwithstanding a great many evasions of the issue and postponements of our anxiety to have the case tried, and we succeeded at the trial upon every point which we contended for. In both of what may be called the key patents of this undertaking—the Edison patents and what are called the Cheeseborough patents, the only two patents out of a great number of others, including the Swan, which were brought up for consideration, attack and defence—the issue was in our favour. If you turn to paragraph four you will see we have told the story in much more concise words than I have explained it, but the two actions which the Company brought against Messrs. Woodhouse and Rawson for

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infringement have been tried, and Mr. Justice Butt has decided both suits in our favour. Well, then we have a little laudation and congratulation, of course. If these judgments are upheld no doubt a great benefit will be secured to the Company. In fact, it secures to the Company, for what it is worth, the value of these patents as commercial machines, and puts, so to speak, a muzzle on infringers. As I said before at the last meeting, there are plenty of people who are quite willing when somebody has taken the risk of producing a serviceable thing to step in between the man who has taken the risk and his profit, and you can only keep them in order by these proceedings and getting these judgments. Well, then, what is going to ensue upon that? The Directors are obliged to take the responsibility of expressing opinions. They say that "the result cannot fail to have a favourable influence on the prospects of the company." Well, we know as a matter of fact, there have been an enormous number of lamps made by different people—Messrs. Woodhouse and Rawson, and a great many others—which have found their way into use, and are in competition with ourselves both in price and as used materials. We do not not know if the people who make them get any profit, or not; but we at all events lose that profit which we should get if we made and supplied them. Well now, that judgment is all specifically in our favour, but of course these gentlemen have the right to appeal. We only wish they would; we are very anxious they should appeal. We are advised by the same eminent counsel who have conducted these proceedings so far, and whose predictions about the result of the proceedings in the first instance have been verified—we are persuaded that if appeal is sought the result will be the same. We have a little inkling of the effect of these judgments from the fact that the orders which have since been received for lamps have materially increased, and we know also as a matter of fact that Messrs. Woodhouse and Rawson themselves have withdrawn their advertisements, and I suppose are not pushing a trade which is under ban, and the pushing of which would entail some rather serious consequences. That is a crumb of comfort one finds in the report. Anyone can do a sum, and will see, to boil it all down, that it comes to this—that notstanding infringements, notwithstanding the slow progress which is being made in electric installations, and notwithstanding the competition which has been going on in virtue of these infringements, we have managed during the year to hold our own. We have not made such a profit as we thought we might have made, but we have not gone back, and in the course of the year, as the accounts reveal, we have been able to get rid of the more dangerous parts of the business—bad contracts in what they call installation rents, and so forth, as I shall explain presently—and also to effect considerable economies in mere working cost, and you will see what results. With a largely diminished sale, and with fixed charges which must necessarily be high, plus the cost of manufacture, we have got pretty nearly an even balance. Well, now, we believe we are treading very safe ground; and it comes to this—every gentleman can induct it from his common sense, the same as we can—if we can increase the output of our lamps, and the sale of our lamps from 161,000, which is what we have sold in 1886, to 286,000, or any other figure you like over 161,000, at practically the same fixed cost—then it does not want any very great arithmetical power to prove that the capital of the Company, which is in round numbers £300,000, is not very far off a dividend, because there is a fair profit upon each lamp. Suppose we put it at 1s. 6d.—100,000 lamps at 1s. 6d. profit—everybody can do that sum, and having got 100,000 in your mind, you can add to that by 25,000, 50,000, 75,000, or another 100,000, and that is really what we ourselves are trying to do. I think I can speak for my colleagues. Mr. Leyland is very much interested in the matter, and takes an enormous amount of pains to follow this out. Lord Anson and other Directors are not indifferent as regards either their pockets or their reputation in regard to this thing coming out right. I think we are all satisfied that what they call "humanly speaking," with these patents secured, with the slow—rather too slow—but still certainly, growing appreciation of the public as to the advantages of this light for the purposes to which we intend to apply it—domestic purposes, factories, and so forth—there is a reasonable prospect that at no distant date, perhaps in this very year, there will be a tangible profit to handle. I have administered this "song of the swan" so often that I sometimes doubt whether I am quite sincere about it, but I assure you that I know I am. I am quite certain about this; I believe this thing is now in such a position that there is a reasonable future—an immediate reasonable future—for the Company, and I am not sure that my conviction and that of my colleagues does not go a little beyond that—that in the course of a moderate number of years there may be a very excellent outlook for this Company, because I am not at all aware that the prosecution of our business to the manufacture of a very large number of lamps involves the outlay of any more money, and I am not aware that the fixed charges of conducting your business—such as rent of premises, rent of offices, and establishment charges—are likely to be at all influenced by a very much greater output of lamps than we are producing now. The only additional cost that I can see attending doubling or trebling the number would be the material and wages incidental to the mere production of the article, and as the profit on the article so produced is a reasonable one—1s. 6d. or something of that sort—if you can produce a quarter of a million one and sixpenses, you can do the sum and see how much dividend that will pay on a capital of £300,000. I know shareholders like to have a little detail. I have told you about the lamps—that there has been a large diminution in the number sold. I have explained that of that number 74,000 is foreign and 41,000 at home; and that I think we are very likely to alter those figures in the course of the present year. That is based on the fact I have just told you, that since the judgment our orders have come in in a much larger proportion than in the corresponding period of last year. In paragraph 5 we state that we have given, as was our duty, notice of the judgment to manufacturers of incandescent lamps who have infringed. Some of these caved in, as it is vulgarly called, at once; they saw it was no use attempting to disregard such a judgment. Others are negotiating with the company, and the shareholders may rest assured that every effort will be made to uphold their rights, which have suffered so seriously by infringements. Of course that is our duty, and it is our right under these judgments; but I see Mr. Sellon looking at me. We are not going to do that in a manner which would be offensive to the public or injurious to our character as men of business dealing with a matter of this sort. We have succeeded already in inducing one at least, and perhaps other large consumers, to adopt the views we put before them, so that they will be left in undisturbed possession of the infringing lamps, merely recognising our right to have the profit instead of the infringing manufacturer. I dare say that is the spirit in which we shall treat all people who meet us in a reasonable way, but if they do not we shall know how to meet them. As long as people are reasonable we shall be reasonable, but if we are driven to defend our rights we shall do so against all comers. There is one other branch of our business which has been a very sad story. I am afraid the history of every man's own career shows that there are many things which he could wish undone, and combinations of men of business are not always wiser, I have found, than individuals. Our combination is one in which we could wish many things undone. One of the worst things we ever did was to believe—well, what shall I say?—on something like speculative knowledge that installation work at rentals was going to be a very excellent business. We have found that not a single installation that our Company has been concerned in from first to last has been anything but a tremendous loss, and when it fell to the lot of the present united Board to sit down after the amalgamation—which after all took place not so very long ago—and "bottom" all this sort of thing, we were face to face with the serious results of mistakes of both companies. Now, we have been working these things down, and last year I had to report that we had got rid of some of these bad things. This year I am happy to say we have got rid of others. Practical experience—other people may be more happy—but our experience may be used for illustrating this proposition: That no installation for the supply of the electric light on rental, on the principles laid down for our guidance, and accepted by the Board under the advice of experts, can possibly land the undertaking in anything but ruin. Of course I am only saying upon our principles. We were told, and it was drummed into us over and over again, and I think I took myself an active part in the proceedings before the Board of Trade and in Parlianent, and every inventor connected with this business had but one fixed idea—that the supply of electricity for lighting could be safely undertaken at about the price of gas. Well, that has turned out to be utterly illusory, and, in our case, the long and short of the matter is that we have lost very heavily upon all those contracts in the mere maintenance—that is to say, that after you have put in the machines and sunk your capital, the mere running of the machines in every case swallowed up all the rent you had got, and you are left with the machinery on your hands high and dry to get rid of at an enormous loss. That is what we have gone through. We have got rid this year of the installation at the Holborn Restaurant to Mr. Gordon. We came out of it very badly indeed, at a very large sacrifice of capital on the original installation, and a very serious loss through the running. Another gentleman, Mr. Gatti, rented an installation, and the results were so bad that, having an opportunity of terminating the agreement in the autumn, we have given notice to do so, and we shall come out of it, I dare say, with a loss. We must pocket it, for it is no good crying over it. The sooner you know where you are in these matters the better. We have one legacy of that kind remaining on hand—that is the Victoria Station—of a distinguished railway company with which I have some connection. Well, that one has some elements about it of consolation, though at the present moment it involves a loss. It was installed for the purpose of lighting not only Victoria Station, but to supply some neighbours, the Brighton Railway, the Grosvenor Hotel, and others. It has not been extended to that for the reason that the machinery first put down was not sufficient to produce the power. We are now supplementing that machinery by other machinery of our own, and we hope the result will be to extend the area of supply, which we can do without infringing or interfering in any way with the Electric Lighting Act, or having to get the sanction of the local authorities, because it is all on private ground, and we hope the result will be, if not to realise any brilliant profit on the outlay, at all events to remove any serious loss. Therefore, what we are going to do is very much this—we know with regard to the lamp business there is good reasonable hope that that will largely increase, and will bring us considerable profit; with respect to the installation business, we know that the heavy loss resulting from that up to the present time is now nearly wholly removed. The seventh paragraph says that installation work on payment has been very slack during the past year. There is no doubt that is so. You will remember that last year, under the inspiration of the Board of Trade, a committee of the House of Lords was appointed to consider the Electric Lighting Act of 1882. There are still some people so sanguine as to believe that electric lighting for public purposes on a large scale can be carried on under the conditions of that Act. There was a long inquiry. Lord Camperdown was chairman, and we had a great many distinguished men on the committee. Sir Frederick Bramwell said that it was quite impossible that electric lighting on anything like a large scale could be conducted in London—at least, under the provisions of that Act. The Board of Trade seemed to think that all that was wanted was an extension of the period from 21 to 42 years. That was all that they could concede. In regard to all the other vital questions they were left exactly were they were. The insertion of a clause, which the committee declined, was wanted in the Bill which was promoted in the House of Lords. The result of it all was that the Bill was withdrawn, and therefore the Electric Lighting Act stands exactly as it did before the Bill was introduced, and electric lighting, in London, at all events, remains practically impossible. Of course, while people were believing that they were going to have very

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soon, under some amended legislation, a kind of public supply of lamps in their houses, it was not a very good time for private installations. I think it not improbable that that may account for a period when the installation business was practically suspended. Well, then, the secretary reminds me—I do not know whether I ought to confide this to an appreciative public through the press; but the fact is, and of course everybody can see it—that if you make a lamp to last for ever, there can be no renewals of it; and really our lamps under improved processes are made to last so long that when once an installation is equipped, the percentage of renewals is generally diminished. Whereas it used to take, let us say, 25 per cent. in the shape of new lamps in the course of a year, renewals are now down to something like 12½, so that there is at once a factor rather telling against ourselves. Perhaps it is not impossible that when a lamp becomes so greatly improved in life and efficiency by the application of skill and science the price may go up. I dare say every man of business here can understand that the percentage of renewals has diminished with the improvements in the lamps, but the price of the lamp remains the same. I do not know that I have anything more to say on the report. If anybody would like to analyse the accounts or to ask any questions upon them, I shall be happy to go through them. I will first advert briefly to them. The proprietors have got them before them; they are pretty simple. About the share capital, I may say that remains exactly as it did last year. There are 17,000 odd A shares paid up, 89,261 A shares £3 paid, and 23,564 B shares fully paid—£5 each. The B shares are entitled to one-fourth of the profits after a cumulative preferential dividend of 7 per cent. has been paid to the A shares. That is not an immediate contingency, for there is a very large amount of preferential interest due. Then there are sundry credit balances—£13,350, and the profit and loss balance of account for the current year is £24. 5s. 6d. Now, I thought myself, when I saw that, that it was surely very humiliating that we should have spent the whole of the year in making only £24. 5s. 6d. I have, however, explained the reason of that, and I cannot attribute to any gentleman in this concern responsibility for the falling off in the sale of lamps which might have made that £24. 5s. 6d. £12,000 or £15,000. On the other side of the accounts is the investment of your money. Well, that is a very old story. As I said before, what is the good of crying over spilt milk? When that money was invested in that way the people who did it were very unwise; but they were only unwise in common with the rest of mankind. Everybody thought that it was to be a gold mine, and very large sums of money were paid for patents, which turned out to be exceedingly doubtful, and involved a very large expenditure to establish them legally, and on the theory that those patents would realise very large results. Up to this time they have not done so. I do not know whether the consciences of those people who received the money are at all tender, or if they are affected by the present outcrop; if they are, they would immediately proceed to refund a large amount of the sovereigns which we paid for what has turned out to be almost worthless. I do not know whether any of them are here; I am afraid not. We have reduced, in the manner shown, the cost of patents, preliminary outlay, loss on working, &c., to £298,354, plus the B shares, £117,820. I have now told you the whole story, and I shall be happy to answer any questions which may be asked.

Mr. F. R. LEYLAND seconded the motion.

Mr. PORTER thought that the Chairman had made a very lucid statement, and had clearly shown that the reason for the small profit last year had been the diminution in the sales of lamps. Were the foreign sales likely to increase?

Mr. PRIOR inquired whether a large sum was not hanging over them for legal expenses, and whether a call might not be necessary.

A SHAREHOLDER asked if the Directors had taken the trouble to find out the value of any reliable asset at the present moment.

The CHAIRMAN, in reply, stated that litigation was going on in connection with the patents abroad, and there was no doubt that while that was pending the sale of the lamps was affected. So far, however, the sales abroad had not decreased. In some of the proceedings they had got the best of it, and in some cases they had got the worst, but no definite result had yet been arrived at, as had been the case with the Company in this country. They were trying to patch up peace between the contending parties. It was a curious fact that the most severe contest abroad should be taking place between the two interests which were happily united at home—the Edison and the Swan. He hoped that the result would be to bring the two together. As to the legal expenditure, the further expenditure "by cost of patents," &c., last year had been £8,104, a considerable portion of which had been for legal expenses on the patent cases. They had decided that it was not fair to charge the income of one year with the cost of establishing this patent, and therefore part of that outlay would be borne by revenue of future years. There was nothing very serious hanging over them. In connection with this matter it would be remembered, as stated in the fourth paragraph of the report, that "the amount due from Messrs. Woodhouse and Rawson under the judgment cannot yet be estimated, and has not been brought into the account." They would now be able to go into the matter, and they had reason to believe that they would have to receive a considerable sum from that firm on account of the lamps sold by them; and of course they would receive the costs of the proceedings. As far as they could see at present, they did not think that there was the slightest possibility of any further call being made. They had a considerable cash balance in hand, and debts and other assets. They had no intention of making a call, and should it be necessary the shareholders would first be consulted. He feared that if they were to wind up to-morrow, the value of the patents and of the B shares—together representing in the balance-sheet an amount of £416,000—would not be much. Then they had their freehold property, standing at £32,000 (less mortgages, £20,300), plant, debtors, cash, &c., amounting altogether to about £70,000, all of which were really good. The resolution was then unanimously adopted.

On the motion of Mr. PORTER, seconded by Mr. PRICE, the retiring Directors, Viscount Anson and Mr. Ernest Villiers, were re-elected; as were also subsequently the auditors, Messrs. Quilter, Ball, and Co.

A vote of thanks to the Chairman and Directors then terminated the proceedings.

Submarine Telegraph Company (Limited).

Report of the Directors to be submitted at the meeting of the proprietors of the Submarine Telegraph Company, to be held at the offices of the Company, 2, Throgmorton-avenue, E C., on Tuesday, the 3rd August, at 1 o'clock p.m:—

The accounts for the six months ending 30th June, 1886, show that the joint receipts amounted to £62,643. 4s. 1d., and the expenses to £27,303. 13s. 3d. The receipts are less than those for the corresponding six months of 1885 by £4,152. 12s. 10½d., and the expenses are greater by £3,006. 5s. 9d. The net profit is therefore reduced by £7,158. 18s. 7½d. The result of the half year's business enables the Directors to add the usual proportion of the gross receipts to the reserve fund; to recommend a dividend at the rate of 12 per cent. per annum; and to carry over a balance of £523. 5s. 7d. to the new account. The falling off in the receipts is due in a considerable degree to the reduced length of the messages. The average length of the messages in 1886 was 11·05 words, against 11·72 words in 1885, and the number of messages transmitted in the half-year was 20,777 more, but the number of words was 747,315 less than in 1885. The falling off in the receipts is also partly due to the diminished traffic received from the Indo-European Company and the Eastern Telegraph Company. The increase in the expenses is to be accounted for chiefly by the increase in the salaries of clerks; an additional amount paid to the French Government for the services of their staff; and by the increased cost of the repairs to the Company's cables, amounting to £2,095. 12s. 11d. This increased cost arises from the insertion of a new length of about five miles in the Havre cable to remove some faults in the conductors, and from the repair of four other cables broken on more than one occasion in the half year in the usual manner, viz., by dragging of ships' anchors. During the whole of the years 1884 and 1885 there was a remarkable immunity from these accidents. The result was that the drawback paid by the insurance company for the time the repairing vessel was in port extinguished the usual half-yearly charge for insurance in the accounts for the six months ending December, 1885, and left a balance, which has greatly reduced the ordinary charge for the present half-year. The cables belonging to the Government in the North Sea have not been interrupted in the half-year. All the Company's cables, as well as those worked by the Company, are at the present time in good working order.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. JULY 28.		BUSINESS DONE WEEK ENDING JULY 28. Highest.	Lowest.
Anglo-American	32½,	33½	33½	32⅝
Do. Preferred	53½,	54½	55	53½
Do. Deferred	10½,	10⅝	10⅝	10½
Brazilian Submarine	10½,	10⅝	10⅝	10½
Cuba	10⅜,	11¼	11	10⅜
Do. Preference	18½,	19½	—	—
Direct Spanish	1½,	2	—	—
Do. Preference	9,	10	—	—
Direct United States Cable	9,	9½	9½	9
Eastern Telegraph	11⅜,	11⅝	11⅝	11
Do. 6 per Cent. Preference	14½,	14½	14⅝	—
Do. 5 per Cent. Debentures, 1899	107,	110	—	—
Eastern Extension	12⅜,	12½	12½	12⅜
German Union	9½,	9⅝	—	—
Globe Telegraph and Trust	6½,	6⅝	6 11-16	6½
Do. Preference	13½,	13⅝	13 7-16	13⅜
Great Northern	12½,	12⅝	12⅝	12½
Indo-European	35,	36	36	—
Reuter's	6,	6½	6	—
Submarine	200,	210	—	—
West India and Panama	⅝,	¾	—	—
Do. 1st Preference	8½,	9	9	8⅜
Western Brazilian	6⅞,	7⅛	—	—
Western Union 7 per Cent. 1st Mortgage	118,	122	—	—
Do. 6 per Cent. Sterling Bonds	103,	107	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	13-16	15-16	—	—
Oriental	3-16	5-16	3-16	—
United Telephone	13⅜,	13⅝	13 9-16	13⅜

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	2¼,	2⅜	2⅜	2⅜
Do. (fully paid)	4,	4¼	4	—
Swan	1⅜,	1½	—	—
Maxim-Weston	3-16	5-16	—	—

MISCELLANEOUS.

Telegraph Construction	38	39	39⅜	38½
India Rubber, Gutta Percha, and Telegraph Works	23	24	23⅝	23⅜

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NOTES.

VALPARAISO.—The Edison electric light system is about to be introduced in the City of Valparaiso, Chili.

PERSIAN CABLE.—The cable between Fao and Bushire, which has been interrupted for about three months, is now restored.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 30th inst. amounted to £2,461.

THE WEST COAST OF AMERICA TELEGRAPH COMPANY.—The gross earnings of this company for the month ending July 31st were £3,050.

THE CITY AND GUILDS OF LONDON INSTITUTE.—The honour of knighthood has been conferred on Mr. Magnus, the secretary and manager of this institute.

INSURANCE.—The American electric light companies are taking steps with a view to forming an association for the mutual assurance of their stations.

THE TELEPHONE IN SWITZERLAND.—Direct telephonic communication will shortly be established between the little town of Aarau and the exchange at Zurich.

EASTERN TELEGRAPH COMPANY.—The traffic receipts of this company for the month of July amounted to £43,708, against £48,081 in the corresponding period of last year.

DIRECT SPANISH TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the month of July amounted to £1,270, against £1,284 in the corresponding period of last year.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY.—The traffic receipts of this company for the month of July amounted to £34,931, and to £46,099 in the corresponding period of 1885.

TELEPHONE CONVERSATIONS AS EVIDENCE.—In a recent case at the St. Louis Circuit Court, U.S.A., the Judge decided that telephone conversations are admissible as evidence, even when the speaker's voice is not recognised.

THEATRE DU PALAIS ROYAL. — The electric lighting apparatus which is now being put up at the Theatre du Palais Royal is rapidly approaching completion. It is expected that by the time the house reopens the installation will be finished.

WEST AFRICAN CABLES.—We learn that the Silvertown Company's telegraph ship, the "Dacia," has laid the shore ends at Accra for the Accra-Grand Bassam and Accra Porto Novo sections of the West African Telegraph Company's system.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 30th July were £2,037, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

THE ELECTRIC LIGHT IN THE CANARY ISLANDS.—Spanish advices from the Canary Islands state that, should the proposals made by an English firm be accepted by the authorities, the whole of the city of Las Palmas will shortly be illuminated by the electric light.

INCANDESCENT LAMP PATENTS IN AMERICA.—It is stated the Consolidated Electric Light Company of the United States are about to bring an action against the Edison and other companies for infringement of the U.S. patent of Sawyer and Mann, of which they are the owners.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended the 31st July were £2,376, as compared with £2,602 in the corresponding period of 1885. The April receipts, estimated at £5,762, realised £5,699.

EXTRAORDINARY TRANSMISSION OF POWER.—A friend writes:—"I think the most astonishing thing I saw in the [Indian and Colonial] Exhibition was a dynamo which the placard stated was supplying current to drive two motors, 'one in South Africa and the other in New Zealand.'"

DAMAGING TELEGRAPH POSTS.—At the Worksop Police Court, last week, George Jackson, John Hanstock, and Chas. Whitehead, all of Carlton-in-Lindrick, were charged by Police-constable Empson with damaging insulators on telegraph posts on the 25th July. They were discharged on payment of costs.

THE TOWER SYSTEM.—A tender has been submitted to the Municipal Council of Columbus, Ohio, for lighting the town upon the tower system. It is proposed to erect forty-three towers, each carrying four lamps of 200 candle-power. The price asked for the maintenance was slightly under $4,000 per month.

HONOUR TO TELEGRAPHISTS.—On the proposition of the French Minister of War, M. Glin and M. Jacques have been nominated for the grade of Knights of the Legion of Honour, the former for 23 years and the latter for 27 years' distinguished service in connection with the military telegraphs of France.

THE TELEGRAPH IN ALGERIA.—The telegraph system in Algeria has recently been extended by the establishment of several permanent heliographic stations. By this means communication is now maintained with the Dabila Oasis, which is 200 kilometres to the south of Biskna, where the electric system terminates.

ELECTRIC LIGHTING IN BANKS.—The Union Bank of Australia, a portion of which is being rebuilt, has decided at the same time to adopt the electric light. The order for this work has been entrusted to the Electrical Power Storage Company, in view of the success which they have already obtained with this class of lighting.

HOTELS LIGHTED BY ELECTRICITY.—The Hotel Schweizerhof, at Lucerne, is now lighted by means of 600 Edison incandescent lamps, and the installation is about to be increased by 600 more of the same kind. The Hotel National of the same town, following the example set by its rival, will shortly be lighted by the Edison system.

CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this company during the month of July was 3,411, estimated to produce £2,800, against 3,058 messages, producing £2,517 in the corresponding month of last year. The traffic receipts for the month of April, estimated at £3,300, realised £3,349.

BOOKS RECEIVED.—We have received a small *brochure*, entitled "Electric Lighting for Private House," from Mr. Wilson Hartnell, of Leeds. The pamphlet directs attention principally to the superiority of the electric light from a sanitary point of view. A sheet of drawings of electroliers is appended; some of these show new designs of much elegance.

WANT OF CONFIDENCE.—The new theatre at Halle is to be lit by electric light. It appears, however, that the management has no great confidence in the system, for in the whole of their contracts with their *employés* it is expressly stipulated that in the event of any performance being interrupted by the

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extinction of the electric light no payment shall be made for that night.

CORED CARBONS.—Cored carbons are now being made in America by a new process. The harder carbon is first moulded in the form of a hollow cylinder and thoroughly baked. The soft material is then introduced to form the core, and after this the rod undergoes a further process, the details of which are not made known. These carbons are said to have given very satisfactory results.

A TELEPHONE COMPANY SUSPENDED.—The operations of the Meucci Telephone Company at New Jersey have been stopped by the Courts, in consequence of a charge of infringement preferred by the Bell Telephone Company, of Boston. The subscribers already connected with the central offices of the company have been required not to make use of their telephonic apparatus pending the trial.

THE RECENT FIRE AT CLERKENWELL-GREEN.—In reference to the fire which took place at Clerkenwell-green on the 23rd ult., and by which the works of Messrs. Eck, Callow, and Co., and Frederick Young and Co., were entirely burnt out, Messrs. Eck, Callow, and Co. desire us to state that pending the re-establishment of their works all communications should be addressed to No. 11, Clerkenwell-green, E.C.

THE TELEPHONE IN WURTEMRURG.—About sixty verbal communications are made daily between Stuttgart and Heilbronn, by the Van Rysselberghe system. In presence of this success, the telegraph line between Stuttgart and Boeblingen has also been arranged for the telephone. Several Ministers and high functionaries, who were present at the inauguration, expressed a wish for telephonic communication to be established between Stuttgart, Ulm, and Friedrichshafen, a distance of 200 kilometres, or 124 miles.

ELECTRICAL INDUSTRIES IN THE STATES.—A New York correspondent of the *Mechanical World* says that the demand for electrical machinery continues to be the feature of the American market. Within three months twenty-three electric appliance manufacturing companies have been organised, and over 100 cities and towns are now having electric light plants put in. A great deal of experimental work is also being done, and although up to the present the application of electricity as a motor has not been entirely successful, yet experiments continue to be made in this direction.

THE ELECTRIC LIGHT AT HADFIELD.—The enterprising firm of Messrs. Rhodes have decided upon the introduction of the electric light into their large mill at Hadfield. For some time they have been dissatisfied with the price of gas—about 3s. 1d. per 1,000 to mills—charged by the Glossop Gas Company, and having failed after application to get a reduction, have decided upon the alternative named, and have given an order to the Edison Company to that effect. The adoption of this system will involve in the first instance an expenditure of about £3,000, for which outlay they will obtain about 1,400 lights.

THE GAS QUESTION IN CADIZ.—The dispute between the Municipal authorities and the Government with respect to the lighting of Cadiz, to which we referred a few weeks back, appears to be as far from being arranged as ever. The Ayuntamiento maintains that it has a perfect right to authorise the local company to lay pipes, while the Governor, acting upon instructions from the Minister of the Interior, refuses to allow the works to continue. Meanwhile, the dispute is, according to the local papers, becoming daily more acute. The Mayor has resigned and public disturbances are threatened.

THE TELEPHONE AT OSTEND.—The Belgian administrators of the Government telegraphs have, since the 1st of July last, successfully worked a telephone exchange in Ostend. The subscription is 170fr. per annum within a radius of a kilometre from the central office, and for each half kilometre beyond that distance an additional charge of 17fr. 50 is made. The price for a conversation in the public office is fixed at 25 centimes for the uninterrupted space of ten minutes. The exchange is connected with that of Brussels, and subscribers may conduct their communications from seven in the morning till nine at night.

THE LIMIT OF TELEPHONIC COMMUNICATION.—Speaking at a recent meeting of the Belgian Society of Electricians, M. Van Rysselberghe summarised the conclusions to which he had been led both by his own experiments and by observation of what had been done in America. He considers that telephonic communication can be carried on in a manner capable of satisfying commercial requirements over a phosphor bronze wire of 2·1mm. diameter for a distance of 500 kilometres, with a wire of 2·7mm. for 940 kilometres, and with a wire of 5mm. diameter over a length of 1,625 kilometres. He is also of opinion that with the 5mm. wire conversation is "sufficiently good" over a length of 3,250 kilometres.

WHAT IS ELECTRICITY?—We mentioned last week that this question is propounded by Prof. Le Corguillé as the title of some elementary lessons which he is writing in the *Moniteur Industriel*. The Professor now sums up the question as follows:—"Electricity may be considered as the whole range of phenomena which arise from the condensation, the rarefaction, or the movement of the ether either around or in the interior of masses of matter. But, inasmuch as any movement of the ether necessarily implies both rarefaction and condensation, the above proposition in reality attributes the phenomena of electricity to one, unique, primordial cause—a variation of the normal force of elasticity of the ether at any point."

MINERS' LAMP.—At the meeting of the South Wales Institute of Engineers at Cardiff on July 29th, Mr. Sydney F. Walker exhibited a model of the Regent (Maquay) electric portable safety lamp, consisting of four cells of the Regent battery in a case, with an incandescent lamp and switch attached. The battery, weighing 3lb., was stated to be capable of maintaining a 3 candle-power lamp for 10 hours, and of afterwards furnishing sufficient light for the miner to find his way out of the pit. The lamp was very much appreciated by the members of the institute, and so much interest was taken in it that Mr. Walker was requested to prepare a paper upon it to present to the institute at the next meeting.

IMPROVEMENTS IN ACCUMULATORS.—M. Emile Reynier has succeeeded by very simple means in overcoming the difficulty which sometimes arises from the swelling of the plates of accumulators during the process of charge. The plates constructed by M. Reynier are bent to and fro so as to present a succession of shelves or corrugations, and the active material is strongly compressed into the spaces thus provided. This particular feature is not new in itself, but the present improvement consists in bending the plates into the form of an arc of a cylinder whose axis is perpendicular to the direction of the corrugation. A battery of this construction has undergone a trial of some duration at Marly (Switzerland), and is said to have been perfectly successful.

ELECTRIC RAILWAY AT MINNEAPOLIS.—Minneapolis is one of the mushroom cities of the United States, and as such is

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bound to go in for all the latest "developments." Consequently, they have discarded steam for their elevated railway, and have adopted the Van Depoele system of electric railways. The change gives great satisfaction both to the dwellers along the route and to the passengers and servants of the company. The trains are capable of carrying as many as 600 passengers at one time, and this, with the weight of the cars, represents a load of 91 tons. Only very meagre technical details have been supplied, but it is stated that a speed of 17 miles per hour is attained, and that the consumption of coal at the generating station is 3,000lbs. per day of 18 hours.

ELECTRIC LIGHTING AT BRUSSELS.—We understand that Mr. Aylmer has been authorised by the authorities at Brussels to lay underground conductors necessary for the lighting of the central part of Brussels. For some time past the Grand' Place has been lighted by arc lamps, and now the central boulevard, the Place de la Monnaie, the Galleries St. Hubert, and the Place de la Bourse, in addition, are to be lighted. The system adopted is to be that of Messrs. Gaulard and Gibbs, who will furnish the electric light at the same price as gas, but the amount of light which will be given will be far greater than that of gas. The district to be lighted includes five theatres, as well as the largest cafés and shops. It is expected that the installation will be ready by October.

A NEW METHOD OF CONSTRUCTING SCREWS FOR SMALL VESSELS.—In the course of his experiments upon the electrical propulsion of boats, M. Trouvé has devised a cheap and simple method of constructing screws, which appears to be well adapted for the case of vessels of small size. M. Trouvé takes a cylinder of the size required for the shaft of the screw, and he turns an helicoidal groove of some depth upon its surface. In this groove he fixes a series of metal spokes. These spokes are wedge-shaped in longitudinal section, and at the same time they slightly broaden out at the thinner end like a narrow fan. By this means, when the groove has received the full number of spokes their edges are in contact throughout. The adjacent spokes are then soldered together and a brass band is soldered around their outer ends. The screw is thus completed.

ELECTRIC LIGHTING IN ST. LEONARDS.—The Hastings and St. Leonards-on-Sea Electric Light Company are now extending their mains up Warrior-square, with the intention of supplying the electric light to those who require it. On Wednesday evening the light was supplied for the first time to some private houses, and those who saw it were struck by its great brilliancy and steadiness as compared with gas. We understand that further extensions will be made, and mains laid on both sides of the square, to supply the increasing demand. We need scarcely point out the immense saving by using the incandescent lights effected as regards ceiling and wall decorations, paintings, drapery, &c. The Robertson-street Congregational Church is lit up every Sunday evening for Divine service with the lights, which have given entire satisfaction.

A NEW AMPERE METER.—This ammeter, which is the invention of Mr. H. A. Streeter, of Chicago, possesses some claim to novelty. It consists of a cylindrical cup containing a coloured liquid. The bottom of this vessel is made of very thin iron, and has a soft iron armature fixed upon the inner side in the shape of a short cylinder about one-third of the diameter of the cup. Above this vessel is a solenoid provided with an iron case which extends into the cup, almost reaching the armature. A narrow tube enters the lower part of the cup, and then bending upwards is provided with a scale, upon which the height of the liquid can be read. When a current passes through the solenoid, it attracts the armature, and diminishes the capacity of the vessel, thus causing the liquid to rise in the tube. We presume that glycerine or some other non-volatile liquid is employed.

M. TROUVÉ'S ELECTRICAL BOAT.—M. Trouvé has lately been working very hard upon the general question of electrical navigation, and has designed several new features in this connection. His latest motor is said to develop one-half horse-power and to weigh only eight kilos; another weighing 15 kilos yields one horse-power. A speed of 15 kilometres, or over nine miles per hour, is reported to have been attained. At this speed it is desirable to have some means of heralding one's approach. M. Trouvé has therefore designed an electric siren which gives a particularly strident blast. The siren consists of two discs pierced with numerous holes, which are placed close together and rotated at a high speed in opposite directions. A blast of air driven by a circular fan is directed upon the discs, and the whole apparatus is driven by a small motor. The boat is also provided with several incandescent lamps and an arc light projector.

ACCUMULATORS.—Our contemporary the *Revue Internationale de l'Electricité* for June has a translation of an Austrian patent for accumulators. We do not know that it absolutely follows, but it seems to us that this patent savours very closely of English practice. The negative plate is said to be made of 95 parts by weight of litharge finely divided, with five parts of pumice. The latter is used to render the mass less dense and more porous. A leaden grill is used, as with some English makers. The positive plate consists of 95 parts of litharge, 95 parts of minnim, and 10 parts of coke. It will be seen that in this plate the coke takes the part of the pumice stone in the other plate. The manipulation of the materials before the plates are used may, perhaps, differ from our methods, rather tending to a little of the practice of the E.P.S., combined with a little from Franklin, Fitzgerald, and various other makers, and this constitutes a patent.

CHURCH LIGHTING.—The new Herrington Church in County Durham, which has recently been consecrated by the Bishop of Durham, is to be lighted by incandescent electric lights, the current being obtained from the dynamo used for lighting the new Herrington Colliery about a quarter of a mile distant. The cables, which are Messrs. Callender's bitumenised, are carried on poles to the neighbourhood of the church and thence underground into the building. Fifty incandescent lamps in all are used, the centre aisle and chancel being lighted by lamps affixed to ornamental brackets depending from the pillars, and the side aisles by lamps enclosed in Trotter's dioptric diffusers suspended from the roof. The contractors for the work are Messrs. Walker and Olliver, and Messrs. Verity Bros., of Regent-street, have supplied all the fittings. It is understood that this is the first church to be lighted by the electric light in the North of England.

ELECTRIC LIGHT AT ELSWICK WORKS.—A large installation has just been completed at the new steel works of Sir W. G. Armstrong, Mitchell, and Co., at Elswick. As the sheds to be lit were built almost entirely of iron it was considered desirable to employ a low tension system. It was also required that the lamps should be entirely independent of one another, so that in the event of an accidental breakage of a cable no great harm would result. These two conditions are readily fulfilled by the Gülcher system, and the work has been carried out by that company. Two dynamos are supplied, each having an output of 30,000 watts. They are compound wound and run at 460 revolutions, giving 70 volts. The arc lamps

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will be 50 in number when the installation is complete; each lamp requires 15 amperes, and gives 3,000 candles. About 40 incandescent lamps are also hung, and provision is made in certain cases for cutting out an arc lamp and substituting an equivalent number of incandescents. The Elswick Works are carried on night and day, and the improvement is much appreciated by the night gangs.

THE MADRID TELEPHONE SERVICE.—We learn from Madrid that tenders for the telephone service of that city were adjudicated upon in the Ministry of the Interior, on Friday last, the 30th ultimo, when the proposition accepted was that of Mr. Ibo Bosch, banker, of Paris, according to which it is stated the Government will receive 20 per cent. of the profits. Only four proposals were received. A proposal of Señor Aramburu, offering 22 per cent., was refused, owing to the conditions not having been complied with. It is stated that a protest against the adjudication was lodged by the representative of the Spanish American Electric Telephone Company, Señor Rotondo Nicolan. At the time tenders were invited the Madrid periodical *Las Occurrencias* published a series of articles on the telephone service which attracted some attention. The author has now republished them in pamphlet form, under the title of "La Cuestion de los Teléfonos." The author appears to have incurred the displeasure of the Director of Posts and Telegraphs, but his views are said to meet with the approbation of a large section of the public, and his pamphlet has a wide sale.

"A NEW DEPARTURE IN TELEGRAPHY."—Under this heading, a daily paper announces with much *éclat* the discovery of a method of transmitting by wire facsimile reproductions either of sketches or of handwriting. The subject is introduced with the following remarks:—"Hitherto messages have been sent along the wire by means of signs, and these sometimes difficult to understand. Attempts have been made by means of puncturing paper at the far end to make the messages more definite. This has not been found, on the whole, to answer well, nor has it been generally adopted." After the knowledge which the writer thus displays of the "attempts" which have hitherto been made, we are quite prepared to learn that "the difficulty has now been got over, and a discovery has been made which will about complete the mode of transmission, and make it as perfect as can be." But unhappily "the *modus operandi* cannot be explained at present, the patents not having been fully secured" Nevertheless, we are assured that no time is being lost, and "ere long the discovery will be in full operation wherever the telephone or telegraph is employed."

THE NAVIGATION OF THE SUEZ CANAL BY NIGHT.—The question of conducting the traffic of the Suez Canal by night as well as by day came before the directors as long ago as the year 1881, although it was not until December, 1885, that permission was finally granted to mail boats and to men-of-war to proceed through a certain portion of the canal by night. The conditions under which this authorisation has been given have already been published. During the four years from 1881 the directors have carried out a series of experiments with a view not only to permit the regular traffic of the canal to proceed by night, but also to enable them to carry on the work of dredging. This arrangement has been in regular and successful operation for the last two years. The steam barges for removing the slush are each provided with a Brotherhood engine, of 3 horse-power, which drives a Gramme machine, which supplies three arc lamps. These lamps are connected in series, and take a current of 24 amperes. One of these is provided with a Mangin reflector, and is mounted upon the bow, the others being placed upon either side. The steam dredgers are provided with an almost similar plant.

COLONIAL SCIENCE.—In the Canadian Section at the Indian and Colonial Exhibition, many of our readers have probably noticed the Library of Canadian Literature, which has been furnished by the Dominion Government. In the shelves devoted to science we find several Canadian reprints of the standard English authorities; but the original work of the colony, as might be expected, is almost solely confined to geology. In the two volumes of *Transactions* of the Canadian Royal Society—which was founded by the Marquis of Lorne, in 1884—there are, however, a couple of electrical papers, one upon the resistance of a solution of sulphate of copper of different strengths, and one upon a modification of the Wheatstone bridge. The electrical exhibits of the colony are not numerous. Although Canada possesses over 47,000 miles of telegraph lines and about 200 telephone exchanges, yet the exhibit in this section is confined to a few Morse keys and a direct ink writer or two. Under the head of Government Telegraphs there will, however, be found a full-sized model of a semaphore station, such as is used for the lighthouse service. There is also a really fine display of frictional apparatus, including a very large plate machine, which shows evidence of careful design and construction, although of course we are obliged to consider the whole thing quite out of date.

GAS AND ELECTRICITY IN PARIS.—It is reckoned that there are now in Paris 16,044 incandescent lamps, and 2,225 arc or Jablochkoff lights. The *Bulletin Internationale de L'Electricité* of this week gives an interesting analysis of the effect of this large number of lights on the Parisian Gas Company. Admitting that each incandescent lamp replaces one jet of gas, and that each arc light is equivalent to ten ordinary burners, an estimate—which our contemporary considers very moderate, and one which gas manufacturers themselves cannot regard as exaggerated—this would represent in round numbers 38,300 gas burners lost to the Paris Gas Company. At the rate of 140 litres of gas per hour these burners would consume 5,362 cubic metres, taking them to be lighted on an average for four hours a day during the whole of the 365 days of the year. This would amount to 7,755,520 cubic metres, which at the rate of 0·30 centimes per cubic metre would put into the coffers of the company 2,326,656 francs. This sum is very considerable, but there has to be added to it what would be obtained from the sale of residual productions in the manufacture of this great quantity of gas if the electric light did not exist. In the face of such facts it is not surprising that the progress of the new illuminant is attracting in an unusual degree the attention of persons interested in the Parisian Gas Company.

A HUGE LIGHTNING CONDUCTOR.—Most of our readers are probably aware that one of the principal features of the Exhibition which is to be held next year in Paris is to be a tower constructed of steel, and 300 metres in height. The question of protecting the tower from the effects of lightning has been considered by a small committee of French electricians, and they have just presented their report to the Minister of Commerce. They point out that the tower itself, being constructed wholly of metal, will play the part of a gigantic conductor, and will serve to protect a very large space around its base. But in order that its action may be efficient it will be necessary to take great care to make thoroughly good metallic connection with the subsoil, at a depth sufficient to ensure the presence of moisture all the year round. If this be properly done the interior of the tower will be absolutely safe during the most severe electrical disturbance

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of the atmosphere. The earth plates are to be of copper, and they will be connected to each angle at the base of the tower by substantial copper cable. The summit of the tower itself is to be surmounted by a tall copper rod having a gilded point, and supplementary conductors are also to project from the angles of the building near the summit; but these rods are merely attached to the walls of the tower, and will not be continued to the ground as in ordinary cases.

ELECTRICAL ARMY SIGNALLING.—Mr. Eric Bruce made some successful experiments at Lillie Bridge Grounds, at the end of last week, with his remarkable invention for long-distance signalling in time of war. Although we have on a previous occasion fully described Mr. Eric Bruce's balloon in *The Electrician*, we may mention, for the benefit of those who are not familiar with the principle upon which it is worked, that it is made of translucent cambric with a capacity of 4,000ft. It contains six incandescent lamps, perfectly isolated from the gas which surrounds them, and connected with the battery on the ground by a cable which helps as a captive rope. When the balloon is at an elevation of 500ft.. the flashes are visible to the naked eye at a distance of 16 miles, and a message delivered by the Morse code can be read by troops stationed at that distance. The experiments were designed to show the feasibility of attaching lamps to the outside of the balloon, whereby they attain a much higher penetrating power. It has been pointed out by some officers of the Royal Engineers, to whom the invention has been submitted, that it would be useful not only for signalling purposes, but as a preconcerted signal, and as giving a point to march on, or to guide a retreat or advance at night. It has also been shown that it would be of high value as a light for working parties. When the balloon was 15 or 20ft. from the ground, it shed over a wide area, a light by which it was quite possible to read the smallest type.

THUNDERSTORMS.—From certain meteorological statistics recently published in Germany we learn that thunderstorms in that country have during the last thirty years been steadily increasing both in frequency and severity. The number of deaths per annum from lightning has increased in a far greater ratio than that of the increase of population. In the present state of our knowledge of the whole subject of atmospheric electricity the cause of the phenomena of thunderstorms is confessedly obscure. It is, however, very possible that some light would be thrown upon the question by a comparative study of the frequency and severity of storms during a lengthened period and over a wide geographical area. The German *savants* incline to the opinion that the increase is to be attributed to the enormously increased production of smoke and steam which has taken place during the last three decades. But although we may admit this to be to some extent a probable *vera causa*, yet when we consider the very local character of thunderstorms we should naturally expect to find that it would follow that the neighbourhoods of large cities, and especially of manufacturing districts, would suffer the most severely. But the statistics referred to show distinctly that the very reverse is the case. The number of storms attended by fatal results from lightning is far larger in the agricultural districts than in the towns. Upon the other hand, we ought to take into consideration the protective action of lightning conductors with which the prominent buildings in the towns of Germany are well provided.

TEMPORARY INSTALLATIONS.—On Friday evening, July 30th, the dining room at the private residence of Sir Spencer Wells at Hampstead was temporarily installed with the electric light, the current being supplied by means of a Regent primary battery. A 20 candle-power lamp enclosed in a dioptric shade, suspended from a chandelier over the centre of the table, served to illuminate the dining room. The room had formerly been lighted by four gas brackets; but after only a few years the ceiling and walls had been so blackened by the gas that its use had been given up and candles substituted, repainting at a considerable expense having been necessary. Sir Spencer will most probably adopt the electric light permanently. The installation was carried out by Messrs. Swete and Main, of Queen Victoria-street.—On the occasion of a garden party given at the residence of Mr A. P. Montgomery, at Isleworth, on Wednesday last, Messrs. Nalder Bros., of Westminster and Brentford, carried out a very successful temporary installation. About forty 5 candle-power lamps were hung in the trees, and a hand fed arc lamp was also employed. The lamps were supplied from E.P.S. cells, and the effect was, as usual, much admired.—Again Mr. Storey, of Oundle, has recently carried out a temporary installation of 100 incandescent lamps at Barnack, near Stainford, on the occasion of the opening of a Constitutional Club and *soirée*, 60 being used to light a large marquee, and the remainder were distributed among the adjacent trees. Also an installation of about 250 lamps on the occasion of a grand Primrose Demonstration at Burghley Park, the seat of the Marquis of Exeter; about 90 coloured lamps were used in the gardens, and the remainder in the marquees used for dancing, refreshments, &c. The whole of the lamps in both installations were fed by Gramme dynamos driven by portable engines.

UNDERGROUND WIRES.—The following remarks on underground cables by Herr Siemens are given in the *Elektrotechnische Zeitschrift* for last month:—"It will appear wonderful to many that jute is employed as an insulating material, and this is frequently ascribed to economical grounds only, but such is not the case. It is known that Sir W. Thomson has found that the plant fibres themselves are a perfect insulator. This induced us to employ this plant fibre for cables, whilst we made use of a special preparation to insure perfect freedom from damp. But the insulation would not be completely attained if the pores of the jute were not filled after the drying with some substance which is rendered liquid by heat, is a good insulator, and besides is not hygroscopic. It was already known to physicists that caoutchuc oil, obtained by the distillation of caoutchuc, possesses these properties in a high degree. It is a matter of essential importance to fill the pores of the dried insulating layer, and at the same time to make the lead case perfectly compact, which serves to cut off the damp of the ground. The lead pipe is now almost perfect. With underground telephone cables there are two evils to be combated, namely, electrostatic induction, and electro-magnetic induction. The action of both phenomena is to give rise to disturbances in neighbouring wires. The first kind of disturbance may be avoided by surrounding each wire by a conducting coat. This, however, does not entirely ward off the electro-magnetic induction, which can only be obviated by the simultaneous action of currents of opposite direction. To get rid as far as possible of the electro-magnetic induction, we must either use double wires twisted so as to often change their position relative to one another, or an investing coat of good conductivity in order that compensating currents of opposite direction may be called forth. This is carried into effect by means of a closed copper sheath, which wards off the effect of static induction, and to a great extent that of the magnetic too. Alas, this also occasions a weakening of the currents, consequently also of the sound in the telephone. This can, however, never be avoided, since it depends on unalterable natural laws.

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ELECTROMAGNETIC INDUCTION AND ITS PROPAGATION.—XXX.

BY OLIVER HEAVISIDE.

(Continued from page 213.)

Impedance formulæ for short lines. Resistance of tubes.

In the case of a short line, a very high speed is needed in general to make it necessary to take electrostatic induction into account in estimating the impedance. Keeping below such a speed, the impedance per unit length is simply

$$(R'^2+L'^2n^2)^{\frac{1}{2}}$$

This is greater than the common $(R^2+L^2n^2)^{\frac{1}{2}}$ at first, when the speed is low, equal to it at some higher speed, and less than it for still higher speeds. Thus, for simplicity, let the return contribute nothing to the resistance or the inductance; then, using (44*b*), we shall have

$$(R'^2+L'^2n^2)-(R^2+L^2n^2) = \frac{R^2g}{6}-\frac{R^2g^2}{24}\left(\frac{L}{\mu}+\frac{1}{10}\right)+\frac{R^2g^3}{48.90}\left(13\frac{L}{\mu}+\frac{79}{56}\right)-\ldots; \quad (47b)$$

R and L being the steady flow resistance and inductance of the line per unit length (the latter to include L_0 for the external medium), R′ and L′ the real values at speed $n/2\pi$ per second, μ the inductivity of the wire, and $g=(\mu n/R)^2$.

Thus the first increase in the square of the impedance over that of the linear theory is $\frac{1}{6}\mu^2n^2$, independent of resistance; large in iron, small in copper. But as the speed is raised, the g^2 term becomes sensible; being negative, it puts a stop to the increase. We can get a rough idea of the speed required to bring the impedance down to that of the linear theory by ignoring the g^3 term. This gives

$$n^2=4R^2\div\mu^2\left(\frac{L}{\mu}+\frac{1}{10}\right) \quad . \quad . \quad . \quad (48b)$$

The real speed required must be greater than this, and taking the g^3 term into account, we shall obtain, as a higher limit,

$$n^2=4\tfrac{2}{13}R^2\div\mu^2\left(\frac{L}{\mu}+\frac{3}{28}\right) \quad . \quad . \quad . \quad (49b)$$

approximately. We see that the simpler (48*b*) is near enough.

If the wire is of copper of a resistance of 1 ohm per kilom., making $R=10^4$, we shall have, using (48*b*)

$$n=20^4\div\left(L_0+\frac{3}{5}\right)^{\frac{1}{2}}.$$

If the return is distant, we can easily have $L_0=9$. Then the speed required is about 100 waves per second. This is a low telephonic speed, so that we see that telephonic signalling is somewhat assisted by the approximation to surface conduction.

If the wire is of iron, then, on account of the large value of μ, a much lower speed is sufficient to reduce the impedance below that of the linear theory; that is, an iron wire is not by any means so disadvantageous, compared with a copper wire of the same diameter, as its higher resistivity and far higher inductivity would lead one to expect.

But it is not to be inferred that there is any advantage in using iron, electrically speaking, from the fact that the impedance is so easily made much less than that of the linear theory. Copper is, of course, the best to use, in general, being of the highest conductivity, and lowest inductivity. Nor is any great importance to be attached to the matter in any case, for, on a short line, to which we at present refer, it will usually happen that the telephones themselves are of more importance than the line in retarding changes of current.

We also see that in electric light mains with alternating currents there may easily be a reduction of impedance if the wires be thick and the returns not too close. On the other hand, the closer they are brought the less is the impedance, according to the ordinary formula. It should be borne in mind that we are merely dealing with a correction, not with the absolute value of the impedance, which is really the important thing.

Now take the speed midway between 0 and the second speed which gives the linear theory impedance. Then $R^2+L^2n^2$ becomes $R^2+n^2\left(L^2+\frac{1}{24}\mu^2\right)$, wherein use the value of n^2 given by (48*b*). The increase of impedance is not, therefore, in a copper wire, anything of a startling nature.

Impedances are not additive, in general. We cannot say that the impedance of a wire is so much, that of a coil so much more, and then that their sum is the impedance when they are put in sequence, at the same speed.

In passing, I may as well caution the reader against the false idea somewhere prevalent. The increased resistance of a wire is not in any way caused or evidenced by the weakness of the current in the variable period compared with its final strength, a result due to the back E.M.F. of inertia. No matter how great the inertia, and how slowly it makes the current rise, there is no change of resistance, unless there be changed distribution of current. There must always be some change, but it is usually negligible. When, however, as notably in the case of iron, the central part of the wire is inoperative, of course this changed distribution of current means a large increase of resistance, though not of impedance, which is reduced. It is a hollow tube, not a solid wire, that must, to a first approximation, be regarded as the conductor. There cannot be said to be any definite resistance unless the current distribution is definite.

Thus, in the rise of the current from zero to the steady state there is, presuming that there is large departure from the regular final distribution, no definite resistance, and it is clearly not possible to balance a wire in which the above takes place against a thin wire, a conclusion that is easily verified. But the case of simple harmonic impressed force is peculiar. The distribution of current, though not constant, goes through the same regular changes over and over again in such a manner that the total current at every moment is the same as if a true linear circuit of definite resistance and inductance were substituted. This is very considerably departed from when mere rapid makes and breaks are employed.

Consider now the resistance of a tube at a given speed. It depends materially upon whether the return current be within it or outside it. Let there be two tubes, a_0 and a_1 the inner and outer radii of the inner, and a_2 and a_3 of the outer. By an easy extension of equation (28*b*), the form quoted in the last section, the differential equation of the total current is

$$0=L_0p+\frac{\rho_1s_1}{2\pi a_1}\frac{J_0(s_1a_1)-\frac{J_1}{K_1}(s_1a_0)K_0(s_1a_1)}{J_1\ldots-\ldots K_1\ldots} - \frac{\rho_3s_3}{2\pi a_2}\frac{J_0(s_3a_2)-\frac{J_1}{K_1}(s_3a_3)K_0(s_3a_2)}{J_1\ldots-\ldots K_1\ldots} \quad . \quad (50b)$$

the dots indicating repetition of what is above them. The first term is for the insulator between tubes, the second for the inner tube, the third for the outer. Or,

$$0=L_0p+(R'_1+L'_1p)+(R'_2+L'_2p)$$

where R'_1, R'_2, L'_1, L'_2 are functions of p^2, and therefore constants when the current is simple harmonic. The division of the numerators by the denominators, a simple matter in the case of a solid wire, becomes a very complex matter in the tube case. I give the results as far as p^2. It is not necessary to do the work separately for the two tubes, for, if we compare the expressions carefully, we shall see that they only differ in the exchange of the inner and outer radii, and in changed sign of the whole.

For the inner tube we have

$$L'_1=R_1\frac{\mu_1\pi a_1^2}{\rho_1}\left\{\frac{1}{2}-\frac{3}{2}\frac{a_0^2}{a_1^2}-2\log\frac{a_1}{a_0}\cdot\frac{a_0^4}{a_1^2(a_1^2-a_0^2)}\right\} \quad . \quad (51b)$$

where R_1 is the steady flow resistance per unit length. This is the coefficient of p, and is therefore nothing more than the inductance put unit length of the tube in steady flow, the first correction to which depends on p^3. This may be immediately verified by the square of force method.

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The resistance of the inner tube per unit length is

$$R'_1 = R_1 + R_1\left(\frac{n\mu_1\pi a_1^2}{\rho_1}\right)\left[\frac{1}{12} - \frac{2}{3}\frac{a_0^2}{a_1^2} + \frac{7}{12}\frac{a_0^4}{a_1^4} + \frac{2a_0^4\log\frac{a_1}{a_0}}{a_1^2(a_1^2-a_0^2)} + \frac{4a_0^6\left(\log\frac{a_1}{a_0}\right)^2}{a_1^2(a_1^2-a_0^2)^2}\right] \quad . . (52b)$$

To obtain, from (51*b*) and (52*b*), the corresponding expressions for the outer tube, change R_1 to R_2, ρ_1 to ρ_3, μ_1 to μ_3, a_1 to a_2, and a_0 to a_3. The change of sign is not necessary, because it is involved in the substitution of R_2 for R_1. Or, simply, (51*b*) and (52*b*) holding good when the return is outside the tube, exchange a_1 and a_0, and we have the corresponding formulæ when the return is inside it.

Let $a_0 = \frac{1}{2}a_1$. This removes a fourth part of the material from the central part of a solid wire of radius a_1. The return being outside, the resistance is

$$R'_1 = R_1 + R_1\left(\frac{n\mu_1\pi a_1^2}{\rho_1}\right)^2 \times \cdot 012.$$

If solid, the ·012 would be ·083; or the correction is reduced seven times by removing only a fourth part of the material.

But if the return is inside, all else being the same, the resistance is

$$R'_1 = R_1 + R_1\left(\frac{n\mu_1\pi a_0^2}{\rho_1}\right) \times \cdot 503$$
$$= R_1 + R_1\left(\frac{n\mu_1\pi a_1^2}{\rho_1}\right) \times \cdot 031,$$

so now the correction is reduced less than three times instead of seven times, when the return was outside.

This difference will be, of course, greatly magnified when the ratio a_1/a_0 is large; for instance, consider a solid wire surrounded by a very thick tube for return; the steady resistance of the return will be only a small fraction of that of the wire, but the percentage increase of resistance of the outer conductor will be a large multiple of that of the wire. Thus the earth's resistance, which, in spite of its low resistivity, is so small to a steady current, will be largely multiplied when the current is a periodic function of the time.

Now, as regards the high speed resistance of the tube. If the return is outside it is

$$R'_1 = (\mu_1\rho_1 q)^{\frac{1}{2}} \div a_1 \quad . . . . . (53b)$$

q being the frequency. But if the return is inside, it is

$$R'_1 = (\mu_1\rho_1 q)^{\frac{1}{2}} \div a_0 \quad . . . . . (54b)$$

thus depending upon the inner radius when the return is inside, and on the outer when it is outside, for an obvious reason, when the position of the magnetic field where the primary transfer of energy takes place is considered.

Suppose we fix the outer radius, and then thin the tube from a solid wire down to a mere skin. In doing so we increase the steady resistance as much as we please. But the high speed formula (53*b*) remains the same. Now, as it would involve an absurdity for the resistance to be less than that in steady flow, it is clear that (53*b*) cannot be valid until the speed is so high as to make R'_1 much greater than R_1, which is itself very great when the tube is thin. That is to say, removing the central part of a wire, when the return is outside it, makes it become more a linear conductor, so that a much higher speed is required to change its resistance; and when the tube is very thin, the speed must be enormous. Practically, then, a thin tube is always a linear conductor, although it is only a matter of raising the speed to make (53*b*) or (54*b*) applicable.

To get them, use in (50*b*) the appropriate $J_0(r)$, &c., formulæ when x is very large. They are

$$\left.\begin{aligned} J_0(x) &= -K_1(x) = (\sin x + \cos x) \div (\pi x)^{\frac{1}{2}} \\ J_1(x) &= \quad K_0(x) = (\sin x - \cos x) \div (\pi x)^{\frac{1}{2}} \end{aligned}\right\} \quad . \quad (55b)$$

These, used in (50*b*), putting the circular functions in the exponential forms, reduce it to

$$0 = L_0 p + \frac{\rho_1 s_1 i}{2\pi a_1} + \frac{\rho_3 s_3 i}{2\pi a_2}$$

where $i = (-1)^{\frac{1}{2}}$. Here

$$-s_1^2 a_1^2 = 4\pi\mu_1 k_1 a_1^2 p, \quad \therefore \quad \tfrac{1}{2}s_1 a_1 i = (\pi\mu_1 k_1 p)^{\frac{1}{2}} a_1.$$

and similarly for s_3; so we get

$$0 = L_0 p + (\mu_1 p/\pi k_1)^{\frac{1}{2}}/a_1 + (\mu_3 p/\pi k_3)^{\frac{1}{2}}/a_2,$$

Here, since $p^2 = -n^2$, $p^{\frac{1}{2}} = (\frac{1}{2}n)^{\frac{1}{2}}(1+i)$; which brings us to

$$0 = (R'_1 + R'_2) + (L_0 + L'_1 + L_2')p, \quad . \quad . \quad (56b)$$

where

$$\left.\begin{aligned} R'_1 &= (\mu_1\rho_1 q)^{\frac{1}{2}} \div a_1, \qquad L'_1 = R'_1/n, \\ R'_2 &= (\mu_3\rho_3 q)^{\frac{1}{2}} \div a_2, \qquad L'_2 = R'_2/n. \end{aligned}\right\} \quad . \quad (57b)$$

as before given, except that the inner tube was a solid wire.

If, however, the speed was really so high as to make these high speed formulæ applicable when the conductors are thin tubes, it is clear that we should, by reason of the high speed, need, at least in general, to take electrostatic induction into account even on a short line, and therefore not estimate the impedance by the electromagnetic formulæ, but by the more general of the last section, in which the same R′ and L′ occur. As for long lines, it is imperative to consider electrostatic induction. There is no fixed boundary between a "short" and a "long" line; we must take into account in a particular case the circumstances which control it, and judge whether we may treat it as a short or a long line question. To the more general formula I shall return in the following section, merely remarking at present that there is a curious effect arising from the to and fro reflection of the electromagnetic waves in the dielectric, which causes the impedance to have maxima and minima values as the speed continuously increases; and that when the period of a wave is somewhere about equal to the time taken to travel to the distant end and back, the amplitude of the received current may easily be greater than the steady flow current from the same impressed force. And, in correction of the definition in XXIX. of V as the surface potential of the wire, substitute this definition, $Q = SV$, where Q is the charge and S the electrostatic capacity, both per unit length of wire.

(To be continued.)

THE ELECTRO-CHEMICAL EQUIVALENT OF SILVER;

TOGETHER WITH

An Experimental Trial of Methods of Measuring the Intensity of Terrestrial Magnetism.*

BY F. AND W. KOHLRAUSCH, in *Wiedemann's Annalen*, Vol. XXVII., 1886.

The paper contains an account of two series of measurements carried out in 1881 and 1883 respectively. The primary object of the inquiry was to obtain an accurate method of determining electro-chemical equivalents, but during its course a number of subsidiary investigations were made, including a very careful comparison of different methods of determining the horizontal intensity of the earth's magnetism, an inquiry into the efficiency of some new and handy instruments for determining the variations of the magnetic intensity with time and place, and an inquiry as to the accuracy attainable in determining the strength of an electric current by means of the tangent galvanometer. The authors consider, as the result of their observations, that when all possible precautions are taken, the absolute measurement of current-strength can be carried out by the Gauss-Weber magnetic method with an accuracy unattainable by any other means.

The final value obtained by the authors for the electro-chemical equivalent of silver is

$$1{\cdot}1183 \frac{\text{mg. silver}}{\text{sec. amp.}}$$

The result obtained by Lord Rayleigh and Mrs. Sidgwick (*Phil. Trans.* 2, p. 411, 1884), who measured the current-strength by an electro-magnetic method, was 1·1179, which shows a very close agreement with the present value, espe-

* Abstracted from the German by G. de Tunzelmann.

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cially considering that entirely different methods of measurement were employed.

The chief objection advanced by the authors against the direct electro-magnetic measurement of the current-strength was the disturbing effect introduced by the heating of the fine suspending wires of the electro-dynamometer by the strong and long-continued currents required for the voltametric measurements. They therefore decided to confine themselves to the magnetic method of measuring the current strength, for which it was necessary, in the first place, to obtain an accurate determination of the horizontal magnetic intensity at the place of observation, and of its variation during the tangent galvanometer measurements. The observations were carried out in the observatory belonging to the Physical Laboratory at Wurtzburg, which was very free from iron, and from mechanical disturbances. All measurements were made at least twice, and the presence of two observers enabled them to be made with greater rapidity, and gave increased security against slight oversights. Entirely different instruments were used for the two sets of measurements. In the first series a tangent galvanometer with a thick copper ring was employed, and the horizontal intensity was determined by Gauss's method, and also by a bifilar galvanometric method which has been previously described by F. Kohlrausch (*Wied. Ann.*, Vol. XVII., p. 737, 1882). In the second series the current was measured by a specially constructed tangent galvanometer with a single copper wire wound round a turned glass disc, and the horizontal intensity was determined by means of a bifilar magnetometer. The magnetometer used for the second determination differed entirely both in construction and material from the one used for the first.

The hundred Gramme standard of mass and the standard metre employed were both supplied by the Imperial Commission of Weights and Measures, and the standard metre was supplied with a table of errors calculated to 1/200mm. When the investigation was completed it was again compared with the imperial standard length, and it was found to have remained unaltered within 1/24000.

For exact measurements of distance a kathetometer was used, having its rod divided on silver into millimetres, and the telescope which it carried was adjusted by means of a microscope. Glass scales were also used, and were compared with the standard by laying them directly upon it and measuring the differences with the kathetometer, or with a microscope and micrometer.

The chronometer used had its rate determined by Dr. Strecker by astronomical observation.

For the weighings two delicate balances were used, their weights having been previously compared with the standard, and a table of errors drawn up. The correction required for the difference in density between silver and brass was of course allowed for, but the changes in temperature and atmospheric pressure between two weighings were in every case too small to produce an appreciable effect.

In the determination of the weight of the magnets employed, they were too far from the small amount of iron in the balance to be affected by it, and the results were controlled by the use of the second balance.

Measurement of the Scale Distance.

The distance between the mirror and scale was about 3,000mm. or 3,050mm. respectively, and was measured by means of a 4-metre rod of rectangular section, which rested cornerwise upon two supports about 1/5 from its ends. The rod was divided into millimetres, and was frequently compared by means of a 2-metre glass scale with the standard metre.

The distance was determined by two different methods.

In 1881 a small reflecting millimetre scale was fixed to the rod so as to lengthen its scale beyond the zero point, and the silk fibre by which the magnetic needle was suspended was reflected in the scale. In front of the scale on which the deflections of the mirror were observed a weight was suspended by a fine silken fibre; the distance of the fibre from the mirror was measured and added to its small distance from the scale, which gave the distance between the mirror and the scale.

In 1883 this method was improved upon as follows:—Two small reflecting millimetre scales were provided, each having one of its ends sharpened to a point. The points were brought into contact with the mirror and the scale respectively; two silk fibres kept vertical by small weights were then placed so as to coincide with one of the divisions of each of the reflecting scales, and the distance between the fibres was measured by the wooden rod, as shown in Fig. 1.

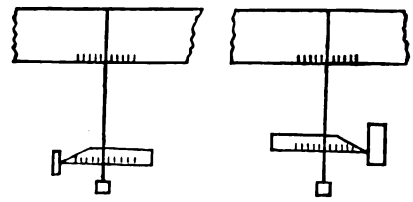

FIG. 1.

The scale was fixed in the vertical by means of a fine stretched fibre, or, if preferred, its deviation from the vertical was allowed for.

It is hardly necessary to point out that in allowing for the thickness of the glass of the mirror 1/1·53 of the actual thickness should be taken.

The thickness of the mirror of the absolute bifilar magnetometer was not known exactly, and therefore the optical thickness was measured directly by taking half the distance through which a microscope had to be moved to bring into focus the image, in the hinder surface, of a point on the front surface previously in focus. The curvature of the mirror and its deviation from the vertical, though usually neglected, may sometimes appreciably affect the observed deflection, and therefore they were allowed for in estimating the distance between the mirror and the scale.

Scale Readings.

In 1881 paper scales were used for the magnetic measurements, but were afterwards discarded in favour of glass ones, owing to the frequent comparison with the standard rendered necessary by their variability. Glass scales were used from the beginning for reading the deflections of the tangent galvanometer. The portions of these scales from which readings were taken were always compared with the standard, and the reduced readings may be depended on to the hundredth of a millimetre.

Local Magnetic Disturbances of the Instruments.

The wide distribution of iron rendered it necessary to test with great care all materials which would have to be in the neighbourhood of the magnetic needles. Metals were avoided as far as possible, and where they were essential electrolytically deposited copper was employed. Brass, especially, was found to be an unsafe material. Some brass screws were found to be magnetic to such an extent that they would adhere to a magnet. Some pieces of brass, on the other hand, were found to be slightly diamagnetic, while others showed no appreciable magnetic susceptibility.

Electrolytic copper usually showed slight traces of magnetism or diamagnetism, which were, however, considerably increased by the process of working up the metal. Great care had to be taken with regard to articles of dress, such as neckties and buttons, also to avoid the proximity of modern note books. Even paper articles were found to be slightly magnetic, but paper and wood were generally found to be practically harmless in this respect.

Ivory, horn, also wood to a slight extent, and marble to a greater extent, were generally found to be slightly diamagnetic. Glass showed slight signs of attraction, which may have arisen from electrical action.

The materials were usually tested by means of a bifilar variometer, used for observations of the earth's magnetism, arranged so that one pole of its strong magnet came close to a thin glass plate. The substance to be tested was then brought within 3mm. of this pole. The delicacy of the instrument was such that a piece of the finest iron wire, 1mm. in length and whose mass was ·05 mg., produced a deflection of 50°.

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This widespread distribution of magnetic and diamagnetic action made it almost impossible to entirely eliminate local disturbances. As, however, this magnetic action of the materials used in the construction of the instruments is always due, in the first place, to external induction, and therefore increases with the magnetism of the needle, it could be very much diminished by using only weak magnets. This being done, the instruments were tested by turning the whole instrument in opposite directions through the same measured angle, and observing the position of the needle in each case. If, after allowing for the effect of the original torsion of the fibre, there was found to be a perceptible disturbing effect, the requisite correction was applied.

Local Differences in the Magnetic Intensity.

The magnetic field in the different places occupied by the absolute measuring instruments was compared by means of the local intensity variometer with four deflecting magnets described by F. Kohlrausch (*Wied. Ann.*, Vol. XIX. p. 130, 1880, and *The Electrician*, Vol. XVII., p. 14). These observations were made alternately with the observations with absolute measuring instruments, and in effecting the interchange gloves were worn to avoid heating the instruments.

Time Changes in the Magnetic Intensity.

These were determined by means of a portable bifilar-magnetometer (F. Kohlrausch, *Wied. Ann.*, Vol. XV. p. 334, 1882), with brass suspension wires 1/20mm. in thickness, and which rested on solid masonry. Before placing the magnet in position it was heated thirty times from 10° up to 50°. Its temperature coefficient was determined by Weber's compensation method.

To test the invariability in the position of the instrument the reading telescope was turned by means of a screw adjustment about its horizontal axis until the image of the scale was seen in the mirror attached to the supporting pillar.

The changes in the intensity were found to be slow and regular, so that it was only necessary to take readings with the instrument at regular intervals.

In 1883, besides this instrument, the time changes in the intensity were also determined by means of the instrument used for determining the differences in the intensity at the different positions of the absolute measuring instruments.

Voltametric Measurements.

The silver solutions were obtained by dissolving nitrate of silver (obtained from two different sources) in pure water. No traces of impurity were found in the salt in either case. The anodes consisted of pure silver. At the conclusion of the measurements solutions of the silver deposit were tested with ammonia and showed no signs of blue coloration.

Crucible Voltameter (Fig. 2).—This voltameter was of the form due to Poggendorff. The cathode consisted of a platinum crucible, with an available surface of about 20 sq. cm. (A silver crucible also was tried, but was found to be unreliable, as even when the washing was repeated many times it continued to undergo a diminution in weight each time.) The crucible rested within a sheet of platinum bent into a cylinder, to which a binding screw was attached. On testing with a delicate galvanometer there was found to be no perceptible short circuiting through the wooden base. To prevent loosened portions of the anode from falling upon the platinum, the former is generally surrounded by filter paper or woollen material; but as it was thought desirable not to have organic substances in contact with the silver solution, the same object was attained by suspending under the anode a small glass cup by means of three glass threads blown into it, and which rested upon the edge of the crucible, an arrangement which was found to answer very well.

Fig. 2.

Siphon-Voltameter (Fig. 3).—Another form of voltameter was tried, in which the cathode consisted of a silver plate with an available surface of about 10 sq. cm. resting upon a plate of spongy platinum, and dipped into the silver solution contained in a small beaker, and the silver anode was placed in the same vessel at a distance of about 3cm. When, however, this was used for an experiment small grains of silver were found at the bottom of the beaker, and as there were no means of knowing whether they came from the anode or the cathode this form had to be abandoned.

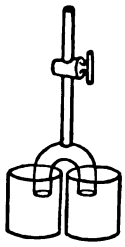

Fig. 3.

Two beakers were then used, connected by a siphon tube, which could be filled by sucking the solution up through a tube attached to the siphon, and provided with a stopcock. A difficulty which occurred in using this voltameter was that directly after the current began to flow it showed a considerable increase in strength, in consequence of the liquid in the siphon tube becoming heated, and consequently having its resistance diminished. This was overcome by using a higher E.M.F. and bringing the strength of the current down by the introduction of external resistance.

Single Beaker Voltameter.—Ultimately the use of a single beaker was reverted to, but the cathode was made to rest in a semi-circular glass cup (Fig. 4), and the cathode and cup were removed together.

Fig. 4.

Before a voltameter measurement was made, a fresh silver deposit was obtained, if not already present, in order that the surfaces should be similar for the two weighings. From time to time the deposited silver was scraped off.

After a silver deposit had been obtained for measurement it was washed, first, with cold, and then with hot water, until the water used, after being allowed to cool, showed no signs of turbidity on treatment with hydrochloric acid. The silver cathode was kept throughout in a small beaker to avoid losing any small portion. It was then dried in an air bath at about 150°, and allowed to cool. It was then weighed several times, until the weight, which at first increased slightly, had attained a constant value, when the final weighing was made. The drying of the crucible was effected by holding it over a flame with the usual precautions.

Tangent Galvanometer used in 1881.

The tangent galvanometer used in 1881 was the one described by F. Kohlrausch (*Wied. Ann.* Vol. XV. p. 552, 1882). The ring was turned out of a copper plate, and it had a rectangular section with a thickness of ·41cm, and a width of ·86cm., with a diameter of about 40cm. The ring was stiffened by means of a wooden triangle. Six different diameters were measured, as a slight distortion was inevitable in removing the ring from the plate of the lathe, and attaching it to the wooden triangle. The temperature was noted at the time of measurement, and the mean diameter determined from these measurements was corrected for the observed temperature of observation. The current was introduced into the ring by making a division in it, and attaching to the two ends so formed conducting leads of copper, to which the connecting wires were attached, as shown (Fig. 5). The requisite correction was applied for the replacement of the small portion of the ring cut away, by these leads.

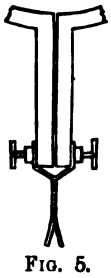

Fig. 5.

It was found by observation with strong currents that the twisted wires exerted no effect upon the needle; their insulation was carefully tested by a delicate galvanometer.

The magnet consisted of a circular steel mirror of diameter $d = 2\cdot08$cm. According to Hallock's researches (*Wied. Ann.*, Vol. XXII., p 411, 1884), the length of the equivalent needle was taken as $2r = \cdot80\ d$, so that the correction factor for the current strength due to the length of the needle will be

$$1 + \frac{3}{4}\frac{r^2}{R^2} = 1 + \cdot12\,\frac{d^2}{R^2}$$

where R is the mean radius of the ring at the temperature of observation, viz. 13°.

The correction for the deflection from the mean plane of the current is small, and for uniform magnetisation of the steel disc we may take it to be the same as for a needle of length $2r$, which gives, for a deflection ω, the factor

$$1 - \frac{45}{16}\frac{r^2}{R^2}\sin^2\omega = 1 - \cdot45\,\frac{d^2}{R^2}\sin^2\omega.$$

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Let h be the thickness of the ring, b its width, l the length of the conducting leads, a the distance between their median lines, Θ the coefficient of torsion, i the strength of the current, and H the horizontal intensity. The equation of equilibrium of the magnet is

$$H(1+\Theta)\sin\omega = \frac{2\pi i}{R}\left(1+\frac{1}{6}\frac{h^2}{R^2}-\frac{1}{8}\frac{b^2}{R^2}-\frac{a\,l}{2\pi R}\frac{R+\frac{1}{2}l}{(R+l)^2}+\cdot12\frac{d^2}{R^2}\right)\cos\omega\left(1-\cdot45\frac{d^2}{R^2}\sin^2\omega\right)$$

which gives, on substituting the values

$$R=20\cdot144,\ h=\cdot41,\ b=\cdot86,\ l=13,$$
$$A=\cdot52,\ d=2\cdot08,\ \Theta=\cdot00021.$$

$$i=3\cdot20724\,H\tan\omega\,(1+\cdot0048\sin^2\omega).$$

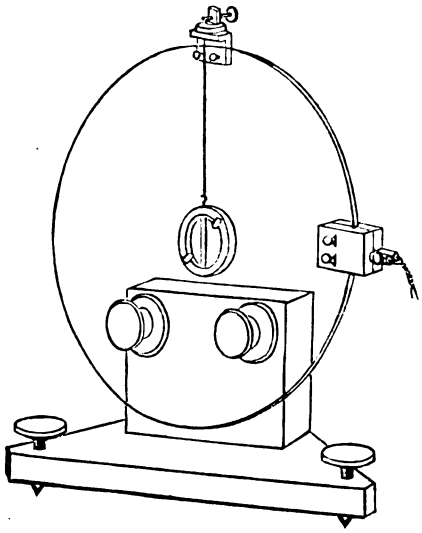

Fig. 6.

Tangent Galvanometer used in 1883.

As the currents employed were not strong enough to require a thick conductor, a single copper wire would suffice for the ring if its shape were kept invariable. A galvanometer was therefore constructed as follows :—

A glass disc about 8mm. in thickness, and 20cm. radius, was turned in a lathe, and a shallow groove made round the edge. Two pieces of ebonite (Fig. 7), grooved to allow the ends of the wire forming the ring to pass through them were attached by copper rivets to the glass plate. The wire being placed in the groove, and the ends drawn through the binding screws attached to the ebonite plates, it was heated by the passage of a strong current, and while still hot the ends were drawn tight by a pair of pliers, and clamped in the binding screws. At the centre of the glass disc a circular aperture was made 5·8cm. in diameter; in this was fixed a small case consisting of an ivory rim (made in two parts to allow of the introduction of the magnetic needle) with glass sides.

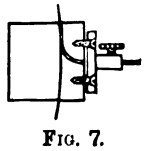

Fig. 7.

The needle was made of a small piece of watch spring attached to a light glass mirror. The suspending fibre was attached to a small copper torsion circle, and hung at a distance of about 1mm. from the surface of the glass, passing through a small aperture in the ivory rim. It was protected from air currents by means of a half cylinder, which could be fixed to the glass disc when required. In order to increase the damping effect two strips of ivory were fixed inside the case about ¾mm. in front of and behind the mirror.

The radius was obtained by measuring the circumference of the disc before the wire was in place. A brass wire ·006cm. in diameter was stretched straight by a weight, a length taken on it nearly equal to the required circumference, and the ends marked. The wire was then rolled round the groove, stretched by the same weight, and the difference between the circumference and the measured distance between the marks on the wire was read off by a millimetre scale. As the diameter of the wire used for the ring was ·058cm., the radius determined from this measurement had to be increased by half the difference in the thickness of the two wires. A second determination was made after the copper wire was in position by measuring four diameters to the outer surface of the wire by means of the kathetometer. The mean of the two results was then taken, and reduced to the temperature of observation.

The ends of the wire, after leaving the binding screws of the instrument, were, as before, insulated and twisted together, and on being tested were found to exert no action on the needle, and to be perfectly insulated.

Where the circuit left the ring a small portion of it was replaced by the curves formed by the portions of wires between the ring and the binding screws. The projection on the plane of the meridian of the surface included between these curves and the portion of the ring which they replaced was $f=\cdot1$ sq. cm. The effect was, therefore, to reduce the force $2\pi i/R$, which the complete circular current would exert at the middle point, by if/R^3 giving the correcting factor

$$1-\frac{f}{2\pi R^2}.$$

The displacement of the needle from the plane of the current was $e=\cdot41$cm., giving the correcting factor

$$1-\frac{3}{2}\frac{e^2}{R^2}.$$

The length of the magnet was $l=1\cdot88$cm. The distance between the poles was taken as $\lambda=\frac{5}{6}l$, giving the correcting factor.

$$\left(1+\frac{3}{16}\frac{\lambda^2}{R^2}\right)\left(1-\frac{15}{16}\frac{\lambda^2}{R^2}\sin^2\omega\right)=\left(1+\cdot13\frac{l^2}{R^2}\right)\left(1-\cdot65\frac{l^2}{R^2}\sin^2\omega\right)$$

Thus the equation of equilibrium of the magnet was

$$H(1+\Theta)\sin\omega = \frac{2\pi i}{R}\left(1-\frac{f}{2\pi R^2}-\frac{3}{2}\frac{e^2}{\pi^2}+\cdot13\frac{l^2}{R^2}\right)\cos\omega\left(1-\cdot65\frac{l^2}{R^2}\sin^2\omega\right)$$

Now at temperature 15°, that of the observations, $R=19\cdot8474$ cm., also $e=\cdot41$ cm. $l=1\cdot88$ cm. $f=\cdot1$ sq. cm. $\Theta=\cdot00004$, so that finally

$$i=3\cdot15739\,H\tan\omega\,(1+\cdot0058\sin^2\omega)$$

The mercury commutator of the tangent galvanometer was arranged so that the direction of the current was changed without breaking it, the galvanometer being momentarily thrown out of the circuit. This short-circuiting did not last more than a tenth of a second, and as the resistance of the galvanometer was a small fraction of the whole resistance it would not produce an appreciable effect.

Magnetometers.

The instrument used in 1881, both for observations of the earth's magnetism and for observations with the tangent galvanometer, was the one described by F. Kohlrausch (*Wied. Ann.*, Vol. 15, p. 550, 1882). Its magnet consisted of a steel mirror, suspended by a silk fibre 14cm. long from a torsion circle, and it was provided with a Töpler damper made of tissue paper, fixed to a light metallic frame.

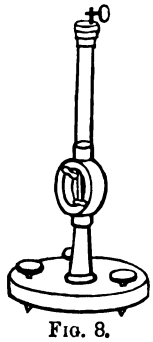

Fig. 8.

The instrument used in 1883 (Fig. 8) contained no metal except the magnetic needle and the copper levelling screws.

The needle consisted of a piece of steel spring, 1·88cm. in length, and it was fastened to a light mirror 2·5cm. in diameter, and swung in an ivory case exactly like the one used for the glass disc tangent galvanometer. The torsion head was made of ivory, and the pillar of horn.

Absolute Measurement of Magnetic Intensity—Gauss's Method, 1881.

The magnet was a solid steel cylinder, 16·01cm. in length, 1·48cm. in diameter, and having a mass of 216·16g. At the middle of the cylinder a conical hole was bored at right angles to its length, in which a small copper cone was placed

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when it was used to produce deflection, and a copper rod carrying a light mirror when it was used for vibration.

After magnetisation, and before being used, it was heated ten times from 12° up to 50°.

Coefficient of Induction.

1. *Weber's Method.*—A coil of copper wire, 40cm. in length and 3cm. in breadth, originally pointing north and south, was turned through 180° about a vertical axis, first empty and then with the magnet within it, and the deflection of a Meyerstein galvanometer in circuit with the coil observed in each case. After the removal of the magnet the value of the scale reading was found by thrusting into, and withdrawing from the coil a small magnet whose moment was known.

F. Kohlrausch has shown (*Wied. Ann.* Vol. XXII. p. 415, 1884) that the increase and the decrease in the magnetic moment due to small forces are practically equal, and therefore the increase in the magnetic moment which would be produced on moving the magnet from the east and west position to the position of vibration, was assumed to be half the change produced by the rotation through 180°.

With reference to a magnetic field of unit strength the increase of the magnetic moment in the normal position was found to be $\mu = 46$[cm.g.].

2. An artificial magnetic field was produced of known strength, about ·2[cm.g.], by winding a known number of turns of wire outside the first coil, and sending through the outer coil a current whose strength was measured by means of a tangent galvanometer in its circuit. The galvanometer readings were observed on breaking, and on closing the battery circuit, both with the magnet inside the coil, and with the empty coil, and the difference taken. The value of the galvanometer readings was determined by the same means as before. This method gave $\mu = 45$.

The value of μ was taken to be the mean of the two results, viz., 45·5.

Moment of Inertia.

The moment of inertia of the magnet was calculated, and also determined by the ordinary experimental method, but the results were found to differ considerably. It was therefore determined by means of a bifilar suspension, and it was afterwards redetermined by the ordinary method with the corrections which Kreichgauer has shown to be necessary owing to the loose attachment of the auxiliary weight (*Wied. Ann.*, Vol. 25, p. 301, 1885), and the three results were in close agreement.

Final Result.

The value E of the electro-chemical equivalent of silver was found to be

As the mean of the observations in 1881

$$E = \cdot 0111833 \text{ [cm.g]} = 1 \cdot 11833 \frac{\text{mg. silver}}{\text{sec. amp.}}$$

and

As the mean of the observations in 1883

$$E = \cdot 0111822 \text{ [cm.g]}.$$

Giving the final mean result

$$E = \cdot 011183 \text{ [cm.g]}.$$

Or a current of 1 ampere will decompose in 1 second 1·1183 milligrammes of silver, ·3280 milligramme of copper, ·010386 milligramme of hydrogen, and ·09327 milligramme of water.

PELTIER'S PHENOMENON IN LIQUIDS.

BY E. NACCARI AND A. BATTELLI.

Two glass cylinders, 16 centim. in width, were placed near each other in a vessel of water, and a paper disc fastened in each half way up. At the bottom of each cylinder was a copper disc 13 centim. in diameter. Solution of blue vitriol was poured in up to the disc, and on this solution of zinc sulphate; in each of these solutions a zinc plate perforated in the centre was suspended. Both zinc plates were connected by a copper wire and a current passed through the apparatus, the intensity of which was determined by a reflecting galvanometer, one division of the scale of which represented an ampere. A very thin perforated glass plate was brought in the centre of each of the paper discs. In this aperture was accurately fitted the bulb of a thermometer, which was surrounded by a caoutchouc tube as far as the part in the aperture. The current of one or two Bunsen elements was sent through the apparatus in either direction, and the course of the thermometer observed every minute. If i and i_1 are the intensities of the current, y and y_1 the corresponding thermal effects, the magnitude of the Peltier phenomenon is given by the formula

$$h = (yi_1^2 - yi^2)/(ii_1^2 + i_1i^2).$$

Only those experiments were taken into consideration in which i and i_1 were not greatly different from each other. With the following intensities were obtained:—

i	63	123	148	187
$10^6 h$	71	64	72	67

The value of h is therefore almost independent of i, and thus Peltier's phenomenon proportional to the intensity of the current.

If when solutions of Glauber's salts of various concentration were superposed on each other, and the bulb of the thermometer was not at the surface of separation of the liquids, or if the same liquid was above and below the diaphragm, no appreciable value was obtained for h, so that the above results are not limited by other influences of heat.

From the experiments as a whole, the value of h is obtained when solutions of the following sulphates are combined with solution of $CuSO_4$ of specific gravity s, and in like manner the solutions of the chlorides with solution of cupric chloride of sp. gr. 1·10. The values of h are positive when the greater heating effect takes place, *i.e.*, when the current passes from the lower and more concentrated solution to the one above it.

Formula.	s.	h.	Formula.	s.	h.
N	—	—	$NiCl_2$	1·115	−60
NiSO.....	1·13	−49	HCl.....	1·029	−46
$Ni(NH_4)_2SO_4$ ...	1·07	12	$MgCl_2$	1·12	−36
$CuSO_4$	1·13	29	$ZnCl_2$	1·19	−23
$(NH_4)_2SO_4$	1·06	29	MCl_2	1·29	+14
Na_2SO_4.....	1 057	52	KCl.....	1·08	24
$MnSO_4$	1·1	64	NaCl	1·068	27
$MgSO_4$	1·09	74	$CaCl_2$	1·15	38
K_2SO_4	1·07	91	$MnCl_2$	1·167	38
$ZnSO_4$	1·137	101	NH_4Cl.....	1·026	52
$FeSO_4$	1·12	106			
H_2SO_4	1·05	120			

The series do not agree with each other. With solutions of various strengths, apart from H_2SO_4 and HCl, h is always positive.

If the entire apparatus was filled with water, and the thermometer was surrounded by a semicircle which was half of iron and half of zinc wire and the current was passed through, the mean of ten experiments was found to be $h = 18$; so that the Peltier phenomenon between liquids is not of a less order of magnitude than between metals. As according to Bellati the electromotive force between zinc and iron is 0·0024 volts, the absolute value of Peltier's phenomenon may be calculated from this for the liquids investigated.—*Phil. Mag.*

A PHYSICO-TECHNICAL INSTITUTE IN BERLIN.—Since Privy Councillor Siemens gave 500,000 marks towards founding an institution for the carrying out of scientific investigations for technical purposes, proposals have been brought forward for carrying the design into effect. The first suggestion of such an institution was made as long ago as the year 1872. In the year 1876 a memorial on this subject was made to the House of Deputies, and in consequence a space was provided for an institute for the practice of technical measurements in the building of the Technical High School. In the year 1883 an extension of the earlier plan was contemplated, which now, from the above-mentioned generous gift of Herr Siemens, has acquired stability. Profs. Foster and Helmholtz have designed a scheme for the institute to be founded.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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UNDERGROUND WIRES IN AMERICA.

The decree which pronounced the doom of overhead street wires in the United States has been enforced with unexpected rapidity and rigour. It was thought in some quarters that compulsory abolition of a system which had grown to enormous proportions during recent years was an empty threat, and that its forcible removal was utterly out of the question. The law, however, has been complied with voluntarily though tardily in most cases, and the few exceptional instances of rebellion have been energetically put down by the local authorities. In New York and Chicago notably electric wires of every description have disappeared or are rapidly disappearing underground; and in other places—Washington, for example—some of the largest companies have already got all their wires out of sight. It is alleged that their progress would have been faster had not an attempt been made to regulate the manner of laying these wires underground, or rather to force upon the proprietors an uniform system agreeable to the recommendations of the local authorities and their advisers. A commission has been sitting to report upon the best means of carrying telephone, telegraph, and electric-light wires in conduits or tunnels below the pavement; and the uncertainty of its final decision has naturally had the effect of delaying the independent action of the various electric companies concerned.

The report of the UNDERGROUND WIRE COMMISSION of New York is now before us, and is precise enough in its recommendations; but for all practical purposes it leaves matters pretty much as they were—that is to say, the companies will be allowed to follow the advice of the commissioners, or let it alone as they please. The commission has no power to enforce its behests, and no funds to carry them out. Its suggestions, moreover, are not of such self-evident value as to certainly win over the authorities to give them the force of law, and the chief indication we can find of their being acted upon to any great extent is the intelligence, which reached us at the same time as the report, that a company calling itself the "Consolidated Telegraph and Electric Subway Company of New York City" has been organised, and is backed by strong financial names, for the purpose of constructing the subways recommended by the commission. The success of this project will depend entirely upon whether the various electric companies choose to make use of it. So far as we have any information on the subject the feeling among the companies has been and continues to be adverse to any scheme which deprives them of independent control over their own particular wires, and over the conduits in which they are severally placed. The leading idea of the Commissioners' Report is to make one conduit or subway serve for all—a very ambitious conception, no doubt, and highly agreeable to the "well-known Wall-street men and bankers," who are said to have "backed" the Electric Subway Company; but not at all satisfactory to the Telegraph and Telephone Companies who have begun operations on their own account, and whose views on the subject of electrical induction appear to have received little attention at the hands of the commission.

As was to be expected, the Electric Lighting Companies are, on the other hand, either favourable to the subway scheme or indifferent. Their position is something like that of the brewer's dray in a crowd of light broughams. Any well constructed conduit is good enough for the electric lighting wires, and if the telegraph and telephone wires do not enjoy the companionship, so much the worse for them. On this point the Report is singularly remiss. A great deal of pains have been taken to discover the best material—asphalted concrete—for constructing the conduits, but little or no attention paid to the necessity for separating the conductors. Indeed, we infer from certain passages that the several classes of wires are to be drawn into one and the same conduit. If we are mistaken in this supposition, then it seems to us the cost of constructing separate conduits for each class of wire, or one conduit large enough to render the proximity of the different wires innocuous, has not been duly weighed. We have nothing to say against the construction of subways made of "asphalte or bituminous concrete" recommended by the commission; they may be cheaper than iron, though the Report is inconclusive on this point; and they may be stronger, though the evidence here is contradictory. They afford protection against external moisture, acids, and gases, no doubt; but the question is, What protection will the respective wires obtain against each other? On this the Report is altogether silent.

It seems also that the wires will require some sort of protection against the asphalte conduit itself, for the composition is found to act injuriously on the insulating material of the wires, so that some quite novel, and probably expensive, process of shielding them from their encasement is admitted to be necessary. One of the objections urged against the alternative of iron pipes is that in case of leakage from an electric wire the current might be conducted to an adjacent telephone or telegraph wire, and start an electric light in somebody's

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house or office where it was not wanted, and might not be easily extinguished. A good many "ifs" go to realise this contingency; but not more than would bring about an identical catastrophe with wires all huddled together in a single conduit. If each set of wires is to take care of itself, then each company will have to take special measures to protect its customers from accident; and of these measures the asphalted concrete conduit, whatever else it may do, takes no account whatever. The argument, therefore, becomes strong for the several companies concerned doing their own work in their own way, subject only to supervision in the interests of public safety. We strongly suspect that this is what will be done, the Commissioners' Report notwithstanding.

In point of fact, some of the best known Telegraph and Telephone Companies are proceeding on that assumption. The WESTERN UNION COMPANY, which has a large interest in Brooks' system of insulating telephone wires, is pushing it forward with considerable energy in New York; and it is alleged that one chief reason why the commission did not report more favourably of this system was because that powerful company had adopted it. Be that as it may, Mr. DAVID BROOKS' simple and effective expedient has prevailed both in that city and in Chicago, and will probably be widely adopted elsewhere, at all events for telephone wires. In the last-named place, as we reported a fortnight ago, three trunk pipes, each containing 500 wires, are being laid under the principal streets, comprising 2,000 miles of wire, with branches at suitable intervals. The pipes are of small calibre, and the wires perfectly insured against induction either on themselves or from neighbouring conductors. No system that has yet come under our notice is at once so effective and inexpensive as this; and as telephone wires must be, in all cases, provided with separate conduits of some kind, there is small likelihood of their being compelled, against the will of their owners, to take up their abode in the bituminous concrete tunnels recommended by the New York UNDERGROUND WIRE COMMISSION.

CORRESPONDENCE.

ABSOLUTE NEGATIVE CHARGE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In a letter in your last issue on the subject of "Ampère's Rule," allusion is made to a theory that "the earth has an absolute negative charge." Evidently, then, this view has some kind of real existence in men's minds. Should there be any among your readers who can claim to have a personal grasp of it, they would gratify me much by explaining where the other boundary of the dielectric lies whose negative terminal is the surface of this earth, "as is supposed." Is there, so to speak, a canal of strained dielectric matter between the earth and Mars? Or is it between the earth and Venus? Though I have met with the theory before, I never regarded it as a serious idea, but merely as one of those grammatical sentences which fetch a high price in marks with the examiner, and with which, accordingly, candidates should charge their memories beforehand.

It appears to me that one absolutely essential feature in all electrostatic phenomena is a canal of dielectric bounded hither and thither by a positive and negative terminal. The sphere of electric strain lies in non-conducting matter. Strain cannot subsist along with yielding, any more than human quarrelling can; and perfect yielding would annihilate strain. Now, in conductors, so far as they are conductors, the particles *yield* to electric force and perform electric motion. When a ball or cylinder of metal lies in an electrostatic field of force, we call those parts negative where the lines of force enter the metal from the dielectric, and the opposite parts, where the lines of force issue from the metal into the dielectric, positive. The dielectric canal is a case of polarity, like a magnet which, when broken, forms parts like the original whole, or like the geometrical polarity of a straight line lying (say) east and west, which exhibits an eastward and a westward end wherever its continuity is destroyed. But I cannot find a meaning in the idea of an "absolute" charge, whether positive or negative, if it excludes this dual or polar conception; such an idea would seem to me to have no place in electrostatics.

I cannot help referring to an excellent letter from Mr. D. G. FitzGerald in *The Electrician* of June 21st, 1884 (p. 127). The writer points out that some mistaken view or other is still held by many "who have not realised that there is an electrostatic *circuit*, which is absolutely analogous to the conductive circuit."—Yours, &c, E. ALDRED WILLIAMS.

37, Burlington-road, W.

RE THE MAQUAY BATTERY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The writer of your note on the above hardly appears to appreciate what the inventor has really accomplished. First, the current delivered by the battery is more constant than that of any other battery I am acquainted with. If you make up a cell to give a certain current for a certain time, it will maintain that current absolutely constant for that time, falling very slowly afterwards. Secondly, the amount of energy obtained from a cell of a given size and weight is very largely in excess of that given by *any* other form that can be used for practical works.

As an instance of this, a battery contained in a box 3½in. cube, and weighing only 7lb., maintained a current of one ampere for four hours, and then fell very slowly for a further three hours, the difference in the light given for the fifth hour being inappreciable. The portable miner's lamp, which has been worked out in connection with the battery, which will furnish a 3 candle-power lamp for ten hours and at the end of that period have sufficient energy left to enable the miner to find his way out of the pit, weighs only 3lbs. Thirdly, the metal used requires no re-amalgamation, and there is no local action.

I hardly think that any other bichromate battery has up to the present been able to show advantages in practical working equal to the above.—Yours, &c., SYDNEY F. WALKER.

Cardiff, August 2, 1886.

THE EDGERTON MOTOR.

At the recent Novelties Exhibition of the Franklin Institute this motor was exhibited and was awarded a silver medal. The report says "the company exhibited electric motors of several sizes, from one-twelfth to six horse-power capacity, quite simple in construction. The armature is made in one casting, cylindrical in form, split longitudinally into three parts, each of which is supported on the hub or axle by a wide spoke or flange. Upon each of the three flanges is wound a coil of wire, varying in size according to the work required; these coils are connected together at one end of the armature by means of a metal ring, to which an end of each is attached, and the three opposite ends are connected with the commutator. The special advantage claimed for the division into three portions is that there is no dead point in the revolution of the armature, and the form of connection described permits such an adjustment of the coils that the same electrical result will be produced on each of the coils in turn as it reaches the proper point.

"The weight of metal in the armature is placed as near the surface of the cylinder as is consistent with strength, so as to bring it near the field. The ends of the cylinder project as far beyond the coils as the thickness of the layers of wire on the coils. The wire is sheltered by the iron and cannot be injured by abrasion on the field. The field is a cylinder, split in half longitudinally, and closely fitting the armature, so that

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a piece of writing paper could hardly be inserted between them; both the armature and field are turned in a lathe. The winding of the field is upon a series of spools attached to the back of the two parts of the cylinder. The whole is enclosed in an iron shell, to which it is screwed, which supports the bearings and the armature, and forms the yoke of the magnet.

"The inventor claims simplicity of construction and durability; that the armature can be run at any speed without displacing the coils, or permitting them to touch the field; that the metal of the armature is brought nearer to the field; that the counter electromotive force in the wire of the armature is much diminished on account of the wire being further removed from the field."

EARTH CURRENTS.

Mr. T. Merncke Holst, Electrician to the Great Northern Telegraph Company at Shanghai, under date May 28, writes us as follows regarding the earth current storm which occurred there on the 30th of March last:—

Storm commenced here on 30th, 4:20 p.m., Shanghai time, and disappeared about 11 p.m., maximum strength of current, on Shanghai-Nagasaki cable = 3·6 milliamperes; 31st, disturbances from 8 a.m. to 1 p.m., and 5 to 10 p.m.; April 1st, from 10:45 a.m. to 12:30 p.m, and 5:30 to 7:15 p.m.; April 2nd, no disturbance. The strength of the current decreased considerably from day to day, as will be seen from the above diagram.

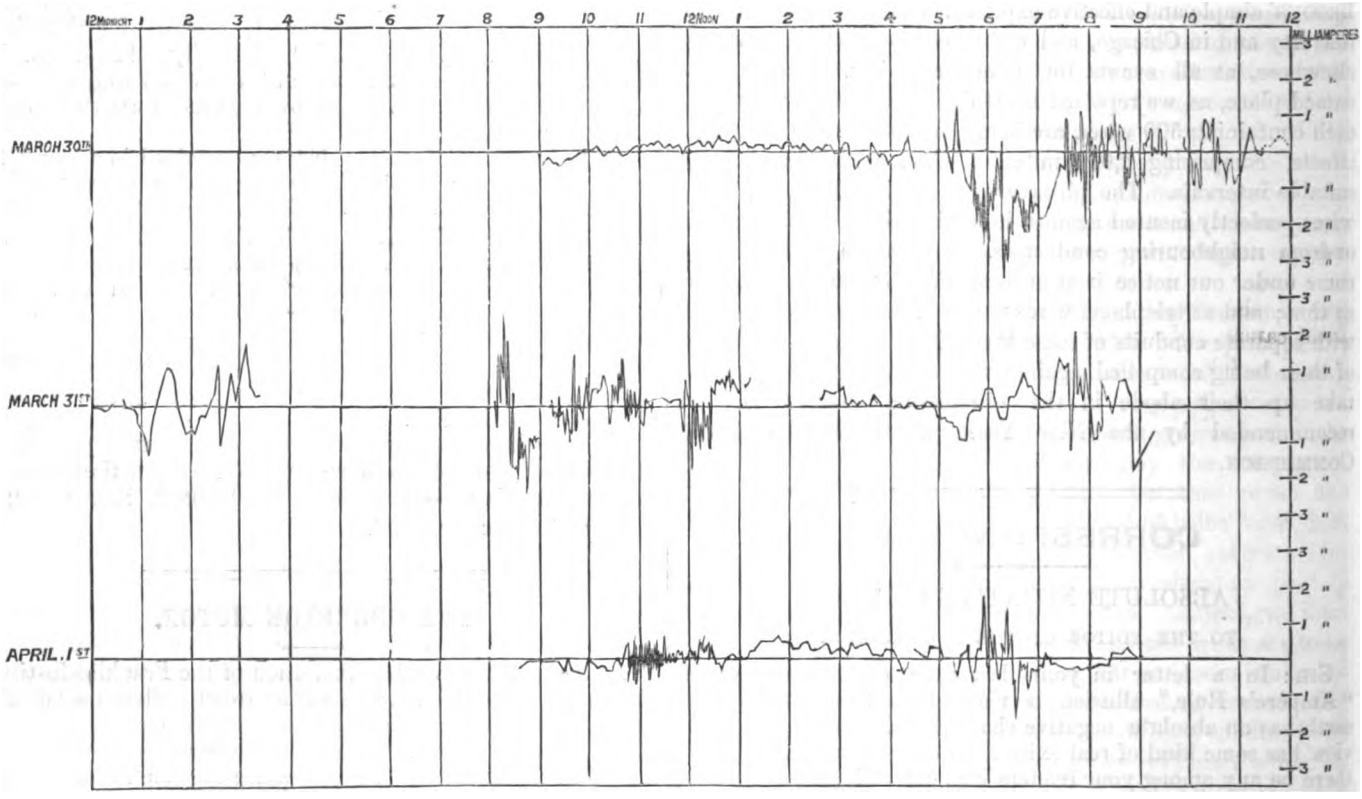

Diagram showing Earth Current Storm on Gutzlaff-Nagasaki Cable.—Shanghai time.

ELECTROMOTIVE FORCE OF VOLTAIC CELLS HAVING AN ALUMINIUM PLATE AS ONE ELECTRODE.*

BY A. P. LAURIE, B.A., B.SC.

In a former number of the *Phil. Mag.* I have given an account of some experiments undertaken with a view of testing whether the E.M.F. of a cadmium-iodine cell was really due to the combination of cadmium or iodine. As there explained, these experiments were made on account of my feeling an increasing distrust of measurements of E.M.F. made in the usual way with infinitely small currents—a distrust not of the measurements themselves, but of our right to assume that the E.M.F. of a particular cell was due to a particular chemical reaction. This doubt is obviously justified when once we realise that impurities far out of reach of analytic detection could easily produce sufficient current for the measurement of E.M.F. in the usual way. On reading the papers published by Dr. Alder Wright in 1885, I was very much struck by the results of his experiments on aluminium-zinc cells, in which he found an E.M.F. actually opposed to that calculated from the thermal data. To quote his figures, he finds that zinc-aluminium cells, with the metals immersed in sulphate of zinc and potash-alum respectively, have an E.M.F. of ·538 volt. According to the thermal data there should be an E.M.F. of ·982 volt in the opposite direction, so that we have a difference of 1·519 volt between the E.M.F. calculated from thermal data and that obtained by actual measurement. Dr. Wright's experiments with other aluminium cells give similar results.

Now, observe that the E.M.F. calculated from the thermal data is obtained by taking the heat of formation of sulphate of zinc and sulphate of alumina respectively, and subtracting the comparatively small heat of formation of sulphate of zinc from the large heat of formation of sulphate of alumina; that, therefore, the assumption is made that this cell is similar to a Daniell cell, and that sulphate of alumina will be formed and sulphate of zinc decomposed, by the passage of the current. The E.M.F. measurement, however, shows an E.M.F in the opposite direction to that calculated on this assumption. How is this to be accounted for? Dr. Wright accounts for it by assuming a "thermo-voltaic constant" of 1·519 volt. By this I understand him to mean that he believes that sulphate of zinc is formed and sulphate of alumina decomposed during the passage of a current, and that an enormous absorption of heat takes place to enable this reaction to go forward. If we believe that we are dealing only with metallic aluminium, sulphate of alumina, sulphate of zinc, and metallic zinc, then we must make the above assumption, and undoubtedly chemical analysis would confirm such a belief.

I think, then, I have said sufficient to show that we have here a point of some importance—that if we have only the above substances to deal with, Dr. Wright has made a surprising discovery. It was to test whether we really had

* From the *Phil. Mag.* for August.

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these substances present that I have made the following experiments.

Before describing the experiments, however, I must say a few words about aluminium itself. It is a metal with some very peculiar and contradictory properties. Though having a very high heat of combination with oxygen, it does not tarnish in the air or decompose water at ordinary temperatures, nor is it soluble in nitric acid. If used as an electrode at which oxygen is set free by the passage of a current through dilute sulphuric acid, it opposes a very considerable resistance to the passage of the current. This resistance has been called "polarisation," and stated as high as six volts. On amalgamating the metal (which can only be done by immersing first in strong caustic) it becomes capable of decomposing water; and its oxidation in the air is so rapid that if left at rest it becomes covered with a growth of oxide in a few minutes, resembling some fungus growths in appearance.

Now, all these properties seem to me to be very easily explained by supposing aluminium to become rapidly coated with a film of oxide, whether in air or water, which, being very insoluble, protects it from all further action, and practically for chemical purposes converts an aluminium plate into an aluminium-oxide plate, unless some solvent of the oxide is present.

Starting with this view, I prepared a solution of aluminium sulphate and of zinc sulphate, enclosing one in a porous pot, and immersed a zinc rod in the zinc sulphate and an aluminium wire in the aluminium sulphate. I did not note the strength of the solutions, as the experiments were merely qualitative. I obtained a deflection on connecting this cell with the electrometer, amounting to about ·54 volt in the same direction as that obtained by Alder Wright. On removing the aluminium wire, cleaning it with sandpaper, and immediately plunging it into the liquid and connecting with the electrometer, a deflection was obtained in the same direction, but only amounting to ·14 volt. After ten minutes it had risen to ·35 volt. This seemed to show that the complete formation of the oxide film took some time. The introduction of a little caustic potash also brought the E.M.F. nearly to zero, but I had not as yet obtained an actual reversal of the E.M.F. of the cell.

I next amalgamated the wire and plunged it in the solution. I at once obtained a deflection of about ·46 volt in the *opposite direction*. At the same time hydrogen was given off, and the wire above the solution became coated with the growth of oxide already referred to.

The next experiment was an obvious one. I plunged two aluminium wires, one cleaned, the other amalgamated, in a solution of sulphate of alumina, and obtained a deflection of 1·08 volt, showing a remarkable difference in chemical properties between the amalgamated and cleaned aluminium wires. In order to test the effect of short-circuiting on the cell, I left a zinc-aluminium cell short-circuited for some days, but the aluminium plate, except for a slight darkening of the surface, remained unchanged, showing that to whatever reaction the E.M.F. of the cell was due, it was of so temporary a kind, or the internal resistance of the cell was so great, that no perceptible chemical change had been brought about.

These experiments are, I think, sufficient to show that there is no evidence that the reactions in the cell are simply the formation and decomposition of the sulphates of zinc and aluminium respectively, but that there is strong evidence to show that we are not in the cell dealing with aluminium at all, but with *aluminium oxide* supported on an aluminium plate. It is therefore more probable that the E.M.F. of the cell is due to the heat of formation of zinc sulphate, – the heat of formation of aluminium sulphate, + the heat of formation of aluminium oxide, – the heat formation of water. These reactions would result in an E.M.F. in the direction actually observed. It may be noticed that even the amalgamated aluminium gives too low a value for the reactions of the formation and decomposition of the sulphates. As, however, the water is being decomposed by the metal, we can hardly tell what the actual source of E.M.F. may be.

I do not know if Dr. Wright attached any definite meaning to the term "thermo-voltaic constant" in the case of these particular cells, as the assumption that the reactions are formation and decomposition of the sulphates is evidently questionable, even from the results he obtained.

This paper is not of course meant as a criticism on Dr. Wright's work, which I have always admired for its accuracy, but merely gives a new interpretation of certain of his experimental results.

ELECTRICAL THEORIES.

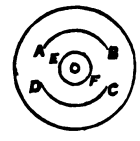
BY PROF. J. J. THOMSON, M.A., F.R.S.

(Continued from page 203.)

There is another way in which the continuity or discontinuity of the current might be tested, and which might perhaps be more delicate than the last. We have seen that at any point of a current at which Σ had a finite value the mechanical force on the element is not at right angles to the element. In addition to the ordinary force at right angles to the element, there is a force in the direction of the vector potential equal in magnitude to the product of the values of the vector potential and Σ.

The existence of this force could be tested by an arrangement of the following kind:—

A B and C D are light movable segments of the same circle, having balls covered with paraffin A, B, C, D fastened to their ends. These segments are connected with a very light framework which can rotate about an axis perpendicular to the plane of the segments; the segments touch at their middle points contact pieces which are connected with a Holtz machine. E F is the section of an electro-magnet concentric



with A B and C D; the whole is surrounded with a metal cylinder to screen it from external electric influences. When current is passing through the electro-magnet it produces a vector potential, whose direction is at right angles to the radius from O, the centre of the electro-magnet perpendicular to its axis. Thus if Σ exists there will be a couple tending to twist the system A B, C D about its axis, but if Σ exists at all it will be when the electrical condition of the balls A, B, C, D is changing, so that unless the currents are continuous we should expect the system to rotate when the balls are being charged up. I have calculated that the system might easily be made sensitive enough to be sensibly deflected on charging or discharging, provided Σ is an appreciable fraction of the rate of change of the surface-density of the electricity on the balls.

*Schiller's Second Experiment.**

Schiller has made another experiment, which shows that Ampère's theory fails for unclosed circuits. The first form of the experiment consisted in having a solenoid placed over a condenser, one of whose plates could rotate about a vertical axis coinciding with the axis of the solenoid. One end of the solenoid was connected to one plate of the condenser, and the other end to the other plate. When the solenoid is connected to a battery the condenser will charge up and there will be radial currents of electricity in the plates; the current passing through the solenoid will produce a magnetic force which will, if Ampère's theory be true, act on the radial currents in the plate of the condenser and set it in rotation. Schiller found that this effect was too small to be observed, so he modified the experiment in the following way. Let us suppose that we have the two plates of the condenser rigidly attached to their axis and placed in a field symmetrical about its axis, in which the vertical component of the magnetic force is not uniform. Then if a current be sent through the upper plate, down through the axis, and out at the lower plate, the couple tending to twist the lower plate will not be equal and opposite to that tending

* Pogg. *Ann.*, CLIX., p. 456; CLX. p. 333.

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to twist the upper one, as the magnetic force is not equal at the two plates, and thus the condenser will be set in rotation. Conversely, if the condenser be set in rotation in the magnetic field, and two electrodes of a galvanometer be connected with its axis, then if Ampère's theory be true there will be an electromotive force acting round the galvanometer circuit, which will produce a current, and this current could be much more easily detected than the rotation in the first form of the experiment. Schiller calculated the deflection which he ought to get if Ampère's theory were true, and found that he could easily detect it if it existed; as he was not able to see any deflection, we must conclude that Ampère's theory is not the true one.

It is easy to see that, according to the potential theory, there would be no current in the galvanometer; for, as everything is symmetrical about the axis, the potential is not altered by the rotation. The following calculation will show that, according to the dielectric theories, there should be no current through the galvanometer.

For if a, b, c are the components of magnetic induction, F, G, H those of the vector potential, X, Y, Z those of the electromotive force, then

$$X = c\frac{dy}{dt} - b\frac{dz}{dt} - \frac{d}{dx}\left\{ F\frac{dx}{dt} + G\frac{dy}{dt} + H\frac{dz}{dt} \right\},$$

$$Y = a\frac{dz}{dt} - c\frac{dx}{dt} - \frac{d}{dy}\left\{ F\frac{dx}{dt} + G\frac{dy}{dt} + H\frac{dz}{ot} \right\}.$$

Suppose the condenser is rotating with an angular velocity ω about the axis of Z; then the E.M.F. arising from one plate is, if R be its radius,

$$\omega \int_0^R cr\,dr - \left(F\frac{dx}{dt} + G\frac{dy}{dt} \right)$$

Now

$$F\frac{dx}{dt} + G\frac{dy}{dt} = \omega R\,\Theta,$$

where Θ is the component of the vector potential along the direction of motion of a point on the circumference of the plate of the condenser.

But the line integral of the vector potential round any curve equals the number of lines of magnetic force passing through it, so that since the field is symmetrical,

$$2\pi \int_0^R cr\,dr = 2\pi R\,\Theta.$$

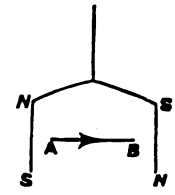
From this equation we see that the E.M.F. due to the rotation vanishes for each plate, so that, according to this theory, there should be no current through the galvanometer.

This experiment of Schiller shows that both Grassmann's and Clausius' theories must be wrong, as well as Ampère's and Korteweg's, for we can easily see that they would make the disc rotate in the way in which Schiller first tried the experiment, and if this were so, it follows from dynamical principles that a current must be produced in the second form of the experiment.

This would seem to be the case even if we take into account the currents in the dielectric, unless we suppose that all the circuits are closed, for if all the circuits are closed then the disc will not rotate, as all the theories agree. If the circuits are not closed we may divide the currents in the disc into two parts, one part being of such magnitude as to form with the dielectric currents closed circuits; then the forces on this part and the dielectric will form a system in equilibrium; and there remains the other part of the currents, the action of the magnet on which ought to set the disc in rotation. Taking Schiller's experiments together, we may say that they show that the dielectric must be taken into account, and that some form of the potential theory is the only one of the theories we are considering which can give the expression for the forces due to a distribution of currents.

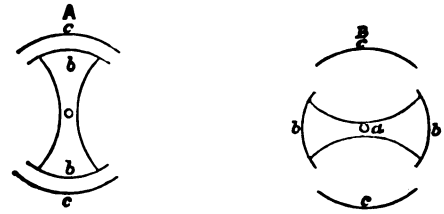
Although these two experiments of Schiller's show that of the theories we have discussed only the dielectric ones can be retained, we shall describe one or two more experiments which have been or could be made to distinguish between the various theories. Clausius' and Grassmann's theories lead to the same expression for the force between two elements of current, so that these theories stand or fall together. Grassmann in his paper* describes an experiment which would distinguish between his theory and Ampère's, or, in fact any other except Clausius', which has ever been published.

Suppose that N S and S N are two magnets whose north and south poles are denoted by N and S respectively, and that these magnets are fastened together by a rod, N S, the system



being suspended by a cocoon thread attached to the middle point of N S. Let A B be an enclosed circuit, say a wire joining the plates of a charged condenser; then, according to Grassmann's and Clausius' theories, the system will rotate in such a way that the sense of rotation is related to a vertical line drawn downwards like rotation and translation in a right-handed screw. According to every other theory it will rotate in the opposite direction.

Another experiment has been made by v. Helmholtz,† which shows that the potential theory leads to wrong results unless the action of the dielectric is taken into account. bb is a rotating conductor, to the ends of which large condenser plates are attached, which, when in rotation, come very near to the similar plates c, c. The plates b and c are segments of coaxial cylinders. In v. Helmholtz's experiments bb was rotated between the poles of a powerful electro-magnet. The plates c, c were connected with a commutator, which put them to earth when the rotating piece was in the position A, and to the plates of a Kohlrausch condenser when it was in the position B. Now suppose there is a difference of potential between b and c; suppose, for clearness, that b is at a higher potential than c, then when the rotating piece is in the position A the positive electricity goes to earth, and the negative is left to go to the Kohlrausch condenser, when the rotating piece gets to



the position B. The change in this condenser was measured by a quadrant electrometer. V. Helmholtz found that the needle of the electrometer was deflected when the piece bb was rotating. Since everything is symmetrical about the axis of rotation, there would be no difference of potential between the plates b and c, according to the potential law, if we neglect the action of the dielectric. According to Ampère's law there will be a difference of potential between b and c equal to $\Theta a\omega$, where a is the radius of the rotating piece, ω its angular velocity, and Θ the vector potential along the direction of motion of the disc. According to the dielectric theory there will also be the same difference of potential between b and c if we suppose that there is no discontinuity in the motion. We shall suppose that, instead of the velocity changing abruptly from ωa to zero as we pass from the rotating conductor to the dielectric, there is a layer of the dielectric next to the conductor in which the change of velocity is very rapid, one side of the layer moving with the velocity ωa, the other side being at rest. Then, using the same notating as before, we have—

$$X = c\frac{dy}{dt} - b\frac{dz}{dt} - \frac{d}{dx}\left\{ F\frac{dx}{dt} + G\frac{dy}{dt} + H\frac{dz}{dt} \right\},$$

$$Y = a\frac{dz}{dt} - c\frac{dx}{dt} - \frac{d}{dy}\left\{ F\frac{dx}{dt} + G\frac{dy}{dt} + H\frac{dz}{dt} \right\}.$$

* Pogg., LXIV. 1, 1845. † *Wissenschaftliche Abhandlungen*, Vol. I., 783.

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Integrating across the thin layer of the dielectric, in which the velocity is changing rapidly, we see that the difference of potential between b and c equals

$$F\frac{dx}{dt}+G\frac{dy}{dt}+H\frac{dz}{dt},$$

where dx/dt, dy/dt, dz/dt are the velocities of a point on the boundary of the moving conductor. This equals $\Theta\alpha\omega$, the same value as that given by Ampère's theory, so that in this case the two theories lead to identical results, which are in agreement with the result of Helmholtz's experiments.

Rontgen has recently published* a preliminary account of some experiments which seem to prove directly that the variations in the dielectric polarisation produce effects analogous to those due to a current.

This completes the account of the experiments which have been made to test the various theories. As the result of them, we may say that they show that it is necessary to take into account the action of the dielectric, but they tell us nothing as to whether any special form of the dielectric theory, such as Maxwell's or Helmholtz's, is true or not.

I have described two experiments which would decide whether Maxwell's theory that all circuits are closed is true or not. It seems to me, however, that even if Maxwell's theory be wrong, Helmholtz's is not the only alternative. I have given a sketch of a theory in which I have tried to make as few assumptions as possible; all that I have assumed is that when a dielectric is acted on by a changing electromotive force, it behaves like a conductor conveying a current whose intensity is proportional to the rate of change of the electromotive force. We know from experiment that it produces effects of the same character, and I have assumed as the simplest assumption I could make that for the same dielectric the equivalent current is proportional to the rate of change of the electromotive force, so that the equivalent current $=\eta$ (rate of change of electromotive force).

Both Maxwell and Helmholtz assume that η depends only on the specific inductive capacity of the dielectric, but I think it is preferable, until we have seen more experiments on this point, to look on η as the measure of a new property of a dielectric, and not to assume that it is merely a function of the specific inductive capacity, the only experimental evidence for this being the by no means perfect agreement between the refractive index and the reciprocal of the square root of the specific inductive capacity. To prove Maxwell's theory of closed circuits it would not be sufficient to prove that for one medium, say air, $\eta=K/4\pi$, for it is quite conceivable that electrical phenomena may be simpler in a dielectric like air, where the electric behaviour of the ether seems to be but little affected by the presence of the dielectric, than in such a one as glass or other substance possessing a comparatively large specific inductive capacity, when the effect of the ether is seriously modified by the presence of the medium.

Since in the theory I have sketched the values of

$$\frac{du}{dx}+\frac{dv}{dy}+\frac{dw}{dz},$$

and $$l(u_1-u_2)+m(v_1-v_2)+n(w_1-w_2)$$

are not zero, but arbitrary, inasmuch as they involve η, in order to find the value of the force between two circuits where there is any discontinuity in the currents we shall require to know the value of the quantity k which occurs in v. Helmholtz's theory.

The most pressing need in the theory of electrodynamics seems to be an experimental investigation of the question of the continuity of these dielectric currents; we have experimental proof that they exist, but we do not know whether Maxwell's assumption that they always form closed circuits with the other currents is true or not. If Maxwell's assumption should turn out to be true, we should have a complete theory of electrical action; if, on the other hand, it should turn out to be wrong, then we should have to go on to determine the quantity k. This quantity is difficult to determine, as its influence on all closed circuits disappears. It influences, as v. Helmholtz has shown, the rate of propagation of the electric potential along conducting wires, and I think we can see that it would influence the time of oscillation of an irregular distribution electricity over a conducting shell. The easiest way, however, of determining this quantity would seem to be the straightforward one of measuring electrostatically the value of the electromotive force due to a variation in the charge of a condenser; the expression for the vector potential, as we saw on p. 140, involves k, so that if we measure the electromotive force, which is equal to the rate of variation of the vector potential, we shall determine the value of the vector potential, and consequently of k.

* *Phil. Mag.* May, 1885.

Appendix I.

Since the report was written I have had through the kindness of the author an opportunity of seeing the advance proofs of a paper by Professor J. H. Poynting, of Mason's College, Birmingham, "On the Connection between Electric Current and the Electric and Magnetic Induction in the surrounding Medium," which is about to appear in the *Philosophical Transactions*.

The views expressed in this paper are rather a new way of looking at Faraday and Maxwell's theory than a new theory of electrodynamic action; as, however, it brings the action of the dielectric into great prominence it is instructive to consider it.

The paper is largely based on a previous one by the same author on the "Transference of Energy in the Electromagnetic Field,"* it is therefore necessary to give a brief account of this paper.

In it the author shows that the rate of increase of the energy inside any closed surface equals

$$\frac{1}{4\pi}\int\int\{l(R'\beta-Q'\gamma)+m(\gamma P'-\alpha R')+n(\alpha Q'-\beta P')\}\,dS$$

where dS is an element of surface, l, m, n, the direction cosine of the normal to dS, α, β, γ the components of magnetic induction, and P', Q', R' given by the following equations:—

$$P'=-\frac{dF}{dt}-\frac{d\psi}{dx},\quad Q'=-\frac{dG}{dt}-\frac{d\psi}{dy},\quad R'=-\frac{dH}{dt}-\frac{d\psi}{dz},$$

where F, G, and H are the components of the vector potential and ψ the electrostatic potential; thus if the medium is at rest P', Q', R' are the components of the electromotive force at the point.

Prof. Poynting interprets this equation to mean that the components parallel to the axes of x, y, z of the flow of energy across *each* element of surface are respectively

$$\frac{1}{4\pi}(R'\beta-Q'\gamma),\quad \frac{1}{4\pi}P'\gamma-R'\alpha),\quad \frac{1}{4\pi}(Q'\alpha-P'\beta),$$

so that according to this view the energy flows in the direction which is at right angles both to the magnetic and electromotive forces, and in the direction in which a right-handed screw would move if turned round from the positive direction of the electric intensity to the positive direction of the magnetic intensity; the quantity of energy crossing in unit time unit surface at right angles to this direction being

$$\frac{1}{4\pi}\cdot\text{Electromotive force at the point}\times\text{magnetic force}\times\text{sine of the angle between these forces.}$$

This interpretation of the expression for the variation in the energy seems open to question. In the first place it would seen impossible *à priori* to determine the way in which the energy flows from one part of the field to another by merely differentiating a general expression for the energy in any region with respect to the time, without having any knowledge of the mechanism which produces the phenomena which occur in the electro-magnetic field; for although we can by means of Hamilton's or Lagrange's equations deduce from the expression for the energy the forces present in any dynamical system, and therefore the way in which the energy will move, yet for this purpose we require the energy to be expressed in terms of co-ordinates fixing the system, and it will not do to take any expression which happens to be equal to it. The problem of finding the way in which the energy is transmitted in a system whose mechanism is unknown seems to be an

* *Phil. Trans.*, 1884, Part 2.

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indeterminate one; thus, for example, if the energy inside a closed surface remains constant we cannot, unless we know the mechanism of the system, tell whether this is because there is no flow of energy either into or out of the surface, or because as much flows in as flows out. The reason for this difference between what we should expect and the result obtained in this paper is not far to seek. Though the increase in the energy inside a closed surface equals

$$\frac{1}{4\pi}\int\int\{l(R'\beta - Q'\gamma) + \ldots .\}dS,$$

it does not follow that the components of the flow of energy across *each* element of surface are $(R'\beta - Q'\gamma)/4\pi$, &c., for we can find quantities u, v, w which are of the dimensions of rate of change of energy per unit area, and for which

$$\int\int (lu + mv + nw)\, dS = 0.$$

(To be concluded.)

MEASURING GALVANIC CURRENTS IN ELECTROPATHY.

Prof. Erb was the first to point out the necessity for using a galvanometer in electropathy, as an indication of the number of cells is not only insufficient but also frequently incorrect. Bichromate batteries are also very uncertain in their action, on account of the continual variation of their electromotive force, which depends not only on the greater or less depth of immersion of the electrodes, but also on the rapid alteration of the surface of the zinc and the chemical composition of the exciting liquid. Horizontal galvanometers possess great advantages over vertical, as the latter are constantly subject to the action of terrestrial magnetism, and even when correctly set at the commencement of an operation they soon give incorrect readings; their sensitiveness also depends on the position of the centre of gravity of the needle and its magnetisation, which latter is subject, under the action of the current, to constant variation.

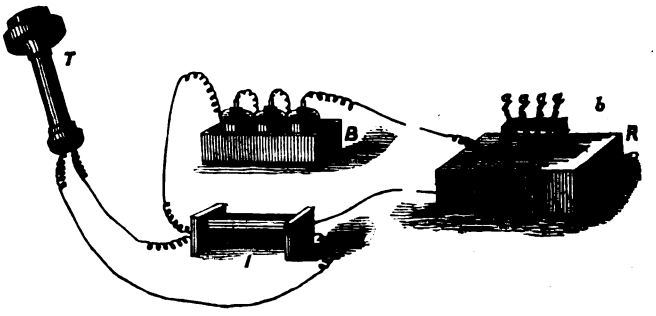
The correctness and constancy of horizontal galvanometers are independent of the magnetisation of the needle, which always returns to zero in the direction of the magnetic meridian, whatever be the force of magnetisation. When the spot is determined where the instrument is to be used, it is easy for the constructor to adjust the galvanometer to the horizontal intensity of the terrestrial magnetism of the locality in question. In order to give horizontal galvanometers the advantages of a vertical reading, which is more convenient than the horizontal for medical use, Dr. Edelmann suggests bending downwards the end of the horizontal needle, and placing a vertical scale on the curved surface of the galvanometer case, thus combining the good qualities of both systems.

A PRACTICAL USE OF THE MICROPHONE.*

In the summer of 1878, the author says that he was at the town of Canton in the eastern part of the State of Ohio, and that he was told by a person concerned, that the main conduit, which brought the water from the lake about three miles off to the town, leaked, without their being able hitherto to ascertain where the faulty place was. The conduit was a clay pipe of about 24in., and lay about 2m. deep underground in a gravelly soil, through which the issuing water trickled and never rose to the surface. The only way to ascertain where the faulty place was, appeared to be to dig at different places till they found it.

The author, however, proposed to observe the noise of the water by means of a microphone, whilst the conduit in question was closed at the end of exit in the pumping station, so that, if the conduit was in good condition, the water in it would be brought to a perfect stand-still, whilst he conjectured that above the place of leakage a sound of the motion of the water would be audible.

The accompanying sketch shows the kind of microphone used. R is a wooden box about 20cm. square, open underneath, and shut at top by a resonance board of thin wood; on this is fixed the piece of bent brass *b*, which is provided above with holes to receive thin sticks of graphite, which fit loosely in them, and the lower ends of which rest in little hollows of the carbon plate K. The battery B is united by one pole to the piece of bent brass, and from this the primary circuit passes through the graphite sticks, the carbon plate, and the primary coil to the other battery pole. The Bell telephone was connected in the customary way with the secondary coil.



After the water had been shut off in the pumping works at the town end, he began operations half-way between the lake and the town. A rushing noise was at once plainly heard in the telephone, which was at first attributed to the wind, but which remained unaltered after the microphone had been sheltered from the wind. The author had taken up a position with the telephone about 5m. on one side, whilst the microphone was directly over the water conduit.

To remove every doubt that the noise arose from the flowing of the water, the microphone was moved gradually farther from the conduit, when the noise became gradually less and less, and finally completely disappeared. Consequently it was clear that the leakage was nearer the town.

The observations were now continued at distances of 40 to 50m., and the noise remained constantly the same for some distance, till at last a sudden diminution in it was observed. Consequently the leak had been passed. The diminution of the noise signified on the author's conjecture a damming of the water. And here he was not mistaken, since the farther back again he went with the apparatus the louder the noise became. In this way he determined the place of leakage within less than 10m. On digging it up the conduit was found to be much damaged at the spot.

ON A NEW MEANS OF CONVERTING HEAT ENERGY INTO ELECTRICAL ENERGY.*

BY WILLIARD E. CASE, OF AUBURN, NEW YORK, U.S.A.

It was shown by M. Henri Loewel (see *The Chemist*, Part VIII., p. 476) that the addition of a solution of chromous chloride to stannous chloride caused a precipitate of metallic tin, the reaction forming chromic chloride. On heating the solution to the boiling point, 212 deg. F., it was found the precipitated metal was in a great measure redissolved, forming the original solution, chromous chloride and stannous chloride, without the liberation of hydrogen. On cooling this solution the tin was again precipitated, the action continuing as often as the solution was heated and cooled.

As chromous chloride has a great affinity for oxygen, it is necessary the air should be excluded from the solution, otherwise the chromous chloride would be reduced to oxychloride of chrome, as Leowel states, and the reactions would cease to take place after a time, the stannous chloride formed during each heating remaining in solution.

I constructed, in the form of a simple galvanic cell, a small element with this solution, chromic chloride,† as the electrolyte, using tin as the positive, and platinum as the negative metal. At 60 deg. F. this element gives no electromotive force, although in this case, when the cell was first set up, it gave 0·0048 volt, owing probably to the presence of some foreign substance.

On the elevation of its temperature by the application of heat, the electromotive force rose and fell, as indicated in the diagram; the curves A, B, C, D, E represent its increase during the rising temperature, and the curves F, G, H, I, J its fall while cooling. The irregularity of the curves A, B, C, D, E was probably due to unequal heating. At the termination of the experiment, when the cell had cooled down to 60deg. F., no electromotive force was

* By Ph. Seubel, in the *Centralblatt für Electrotechnik*.

* Paper read before the Royal Society.

† The solution used was made by combining chromium trioxide with hydro-chloric acid, and heating.

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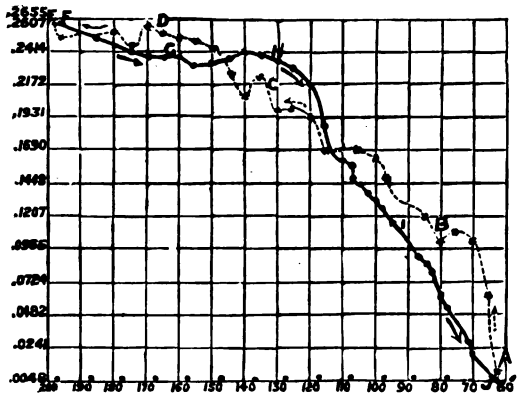
observed, as indicated on the diagram, of which the abscissæ are proportional to the electromotive forces, the ordinates to the temperatures Fahrenheit. The highest electromotive force was 0·2607 volt at 197deg. F., the highest degree to which the temperature was raised. If the platinum be replaced by a negative electrode of carbon, the electromotive force will be higher. It may be of interest to mention that the action of this element during heating is entirely different from that of the galvanic battery during a similar elevation of its temperature.



W. H. Preece, Esq., F.R.S. (*see* "The Effects of Temperature on the Electromotive Force and Resistance of Batteries," *Proc.* Roy. Soc.. Vol. XXXVI., p. 48), states "that changes of temperature do not practically affect electromotive forces, but that they materially affect the internal resistance of cells." When the temperature of this element was lowered to about 145deg. F., the reactions before mentioned took place. The tin taken up by the solution during heating commenced to precipitate, increasing as the temperature lowered, and the metal fell to the bottom of the cell in a form to be again utilised in the generation of the current. The amount of local action or chemical corrosion which took place above 150deg. F. was excessive, but the metal taken up by the solution was very much less when the temperature of the electrolyte was not raised above the point of precipitation, 140deg. F. The metal taken up below this point appears to be precipitated under the same conditions as that taken up at higher temperature, and seems to be precipitated whether the circuit be open or closed.

It will be seen on the curves F, G, H, I, J, with failing temperature, that the electromotive force increased between 150deg. F. and 140deg. F.; this might have been due to the reactions which took place during the precipitation of the metal.

Further investigations to determine the efficiency of this element would be of interest.

ALTERNATING CURRENTS AND THEIR PRACTICAL USES.*

At first only battery, and consequently continuous and constant, currents were known. Their E.M.Fs. are small, and for a single arc light they needed an army of cells which filled a whole room.

Later, after the discovery of induction, when they recognised the physiological action of the current, they made use of induction to generate higher E.M.Fs. They transformed battery currents, which possessed so low an E.M.F. that they could not touch the nerves at all with them, into currents of high E.M.F., which were capable of strongly affecting the nervous system. These currents were either extra currents or secondary currents, produced with a sliding apparatus or Rhumkorff coil. These currents of higher E.M.F. were induction currents, and, what induction always generates, alternating currents.

Hence arose the misconception, somewhat prevalent in Germany, that alternating currents were dangerous.

If we close a battery of a few elements by a circuit in which there is little induction, such as, for instance, a series of glow-lamps, we can break this circuit a hundred times quickly or slowly, without any action being felt. But if the same battery is closed by a conductor of considerable self-induction—for example, by a coil of many windings with an iron core in it, then every interruption will be felt plainly enough. The interruption of one and the same current is in one case physiologically actionless, in the other of strong effect. The interruption itself exercises no action, but the strong E.M.F. and current generated by the induction does.

To illustrate the matter further, let us consider a dynamo machine, with powerful magnetic fields—for example, an Edison machine. The arms of the magnets are wound with immense long coils of copper wire, and these coils are united with the binding screws of the machine to form a shunt circuit. The potential difference at the binding screws amounts to about 100 volts. The magnet coils consequently experience an E.M.F. of only 100 volts. Nobody need be afraid of laying hold of the ends of the wires of these coils with their naked hands, for we know that an E.M.F. of 100 volts is harmless. On the contrary, let any one beware of touching these wire ends at the instant when the circuit of the magnet coil is suddenly broken. By the sudden demagnetisation of the iron there arises in the long coil an instantaneous current, whose E.M.F. may reach many hundred volts. But if we break the outer circuit which is formed of glow lamps the interruption is scarcely perceptible.

Other chance circumstances have assisted to confirm this erroneous opinion. The period, about eight years ago, is remembered, when the division of the electric light, as it was called, was found out, viz., that they could keep up several arc lights in series by one dynamo machine. First came the Jablochkoff lamps, for which Lontin and Gramme invented their alternating machine, and then the division lamps of Siemens, which were fed by Siemens alternating machines. Thus there came for the first time currents with great E.M.Fs. into practical electric lighting, since it is evident that a series of lamps must have a higher E.M.F. than a single one. We now heard for the first time, "Take care, you are warned not to touch the conductors," and, because these currents of high E.M.F. were also alternating currents, they again thought that the danger lay in the currents being alternating. That the continuous currents of Brush, which were soon after introduced with their 1,000 and 2,000 volts., brought more danger than all the alternate currents was not noticed.

It is not the quality of the current, not its duration, direction, &c., which is the test of its danger, but solely the *difference of potential or E.M.F. to which the body is exposed, that is the difference of potential between the two points where the body is in contact with the circuit.* Consequently, an electric current, be it uniform, intermitting, or alternating, may be dangerous if it possesses a high E.M.F., and every electric current is perfectly harmless if it possesses a small E.M.F.—for example, 100 or fewer volts.

From the point of view of safety it is a necessity with all electric currents, whatever their name and origin, that in house conductors and lamps, which are tended by unskilled persons, only such currents should be used as have not a high E.M.F., and that such conductors as carry currents of high E.M.F. should be made inaccessible to unprofessionals.

Again, many think that alternate currents are not so effective as continuous currents. This opinion is also in most cases erroneous.

Let us consider a single coil of wire which we move in a magnetic field. Its plane cuts the lines of force. As long as the number of force-lines inside the coil remains unaltered there is no resistance to the motion, and no current is generated in the coil; only when the motion alters the number of lines of force does the magnetic field offer a resistance to the motion and awake an electric current either in one direction or the other. If the coil move from a weaker to a stronger field, an electric current circulates in one direction; on the other hand, if the motion is from a stronger to a weaker, the current is in the opposite direction.

If we had an infinitely extended magnetic field in which the intensity varied continuously, we could by a continuous motion of the circuit call forth a continuous current. But since this is impracticable in reality, and we have only a limited field in which the coil must move, it is impossible but that we should have currents which alternate more or less rapidly equally whether the motion is rotatory or oscillatory. Consequently, we have always alternate currents in the armature of a dynamo machine, never continuous ones like those of batteries and thermopiles. It is only outside the machine that the current of a dynamo can be made continuous. The commutators serve for this purpose, or the ingenious collectors introduced by Gramme.

There is, indeed, a practical difference between continuous and alternating machines, and in this difference the alternating machines have an advantage. This difference does not exist inside the machine, but in the manner of collecting the currents. The continuous machine must have a commutator or collector, by which its whole current is taken, and that is its weak part. The currents of the alternating machines, on the other hand, are caught in their natural state, and as they have arisen they go out into the circuit, either from contact rings, which have uninterrupted and constant contact, or still better by fixed binding screws direct from the armature.

Even with alternating machines the tiresome process of commutation, alas, is not quite avoided, for these machines also need continuous currents for the excitation of their magnets. But the evil here is much smaller than with continuous current machines, other things being equal. With a 100 horse-power continuous machine, for example, we have to reverse 600 to 700 amperes; with a machine which differs only in being alternating only 20 or 30 amperes, the E.M F. being the same in the two cases.

* Abstract from a paper by Max Deri, in the *Zeitschrift für Elektrotechnik*.

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On this account one is less trammelled in the construction of large alternating machines than in the case of continuous machines. An Edison 1,000-light machine is looked upon as a colossus. On the other hand, an alternating machine for 4,000 to 8,000 lights is no particular masterpiece.

The reason of this lies in the fact that the induced coils need not be brought together to a collector by an innumerable number of connecting wires in an alternating machine like in a continuous machine. The armature wires can rather be so conveniently distributed on the outer periphery of the whole construction as is most suitable for the efficiency. These wire coils may, if we please, be made stationary, whilst the more massive parts of the machine are made to rotate. Such arrangements have hitherto been sought to be made in vain with continuous machines.

Hence arises the fact that alternating machines do not require such rapid rotation as continuous machines. Continuous machines which make less than 500 turns per minute are not frequent. Alternating machines require for the same performance about half the number of revolutions. There are plenty of alternating machines which work with only 150, and even fewer revolutions. That this property from a technical point of view is very valuable, nobody can doubt.

The alternating machines have another advantage over the continuous machines, which in my opinion cannot be enough insisted upon. It is well known how difficult it is to generate with a dynamo machine currents of high E.M.F., for example, of many 1,000 volts. In the armature of a continuous machine, which must form the most compactly constructed part of the apparatus, it is unavoidable pushing very close to one another such points of the current-yielding wires as have very considerable differences of potential. The wire coils themselves are mounted very closely together; their connecting wires and the sectors of the collector are pushed still closer together. The danger of a current of great E.M.F. leaking through from weakness of the insulation is consequently very great.

The relations of rightly constructed alternating machines are much more favourable on these points.

There is no argument to show that alternating machines should not work with just as good, useful effect, and should not be as satisfactory in their performances as continuous machines, and, indeed, I have shown you properties of alternating machines which may enable them to surpass other dynamo machines.

What has just been said refers rather to the alternating machines than to the currents which they generate. Before speaking of the currents we will return to induction. It was shown how electric currents are induced by the motion of a conductor in a magnetic field, and that such currents are in practice always alternating currents. It may be added that this induction, as is well known, is very much strengthened by the use of iron.

The author goes on to speak of the rapid reversal of the magnetic force lines of the iron by an alternating current, and of how this rapid reversal may generate currents in any conductor in their field. He speaks of the great advantage of transformators in the conversion of electric energy.

He says the negative E.M.F. of a coil traversed by a current and consequently also the E.M.F. of a secondary coil depends evidently on the course of alternation of the current and on the properties and dimensions of the matter in which the force lines develop themselves. In induction of force lines iron far surpasses all other bodies. Its permeability for magnetic force lines it has been shown is many hundred times greater than that of air. Consequently, the more iron is employed and the more fully the space in which the force lines describe their path is filled with it the stronger is the action. When the force lines issue into the air, poles are formed and the force lines are dispersed. For the strongest action closed iron circuits should be used which have no poles.

To avoid losses in the induction care must be taken to avoid any metal work (except the secondary coil) coming into the range of the force lines, else the parasitical currents known as "Foucault's currents" will be induced in it.

Good conductors should be used for each kind of induction—iron for the magnetic and copper for the electro-magnetic. It is simplest to employ wires of small cross-section for both. The iron wires are arranged parallel to the force lines engendered by the current, that is perpendicular to the current, and the copper wire of the secondary circuit parallel to that of the primary one. All the wires should be insulated. In such an arrangement no parasitical currents can arise, for the insulation of the iron wires prevents their formation in the core.

He then quotes as an example of a transformator one in which for a consumption of 7,560 watts by the primary coil, the secondary gives 7,200 useful watts, that is, it has an efficiency of 95·2 per cent.

He says that a dynamo machine must always have two defects in comparison with a transformator:—(1) The loss by friction in the motion; (2) the dispersion of the force lines in the air.

The action of alternating currents is to be very much valued, in that it renders transformation possible. It is a benefit to be able to work with high E.M.Fs., which are indispensable to overcome distance, and then to be able to get rid of them, and transform them into comparatively low ones when we no longer require them or they are inconvenient.

The alternating current can be employed just as well as the continuous current for the production of light and warmth. In the production of light there is to be sure some difference in the working, but only with the arc light. The continuous current has here the advantage that it hollows out a crater in the positive carbon, which acts as a natural reflector, and so produces downwards a more favourable lighting effect. On the other hand, an alternating current has the advantage that both the carbons wear out in the same manner.

For glow-lamps the lighting action of both kinds of currents is perfectly equal.

For motors up to the present time the continuous current has been almost exclusively employed. But thereby it is by no means implied that alternating currents cannot also produce motive work. I even assert, and do not rest upon my own individual views alone, but upon the results of experiments which are not yet terminated, that alternating currents will also be found useful in the working of electro-motors, and will enter into competition with continuous currents.

Continuous currents must, however, be given their due in one particular. Alternating currents are useless for electrolysis, and consequently they are unfit for all metallurgical work. They cannot either be employed with accumulators. This province belongs entirely to continuous currents.

This is, however, the only province wherein alternate currents yield to continuous currents; everywhere else they will dispute the field with them.

SOUTH KENSINGTON EXAMINATIONS.

(Continued from page 158.)

Second Stage or Advanced Examination.

Instructions.—Read the general instructions at the head of the elementary paper. You are not permitted to attempt more than eight questions. You may select only two in Magnetism, three in Frictional Electricity, and three in Voltaic Electricity. The value attached to each question is the same.

Time, three hours.

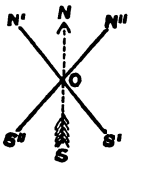
Magnetism.

21. A circular steel disc is magnetised, so that one of its diameters is its magnetic axis. How could you find the magnetic axis by observing the position which the disc takes when it is hung by a silk thread so that it lies horizontally?

A.—When the disc is suspended horizontally, mark some point of its circumference. Invert the disc, again suspend it horizontally with its centre at the same point as before, and mark that point on the circumference which occupies the position previously occupied by the first marked point. The magnetic axis of the disc, being the diameter which occupies the same position before and after the inversion, will be the diameter bisecting the arc intercepted between the two marked points.

22. Two equal and equally magnetised darning needles are thrust through a wooden match at right angles to it; and with the similar poles pointing in opposite directions. If when the match is hung by one end from a silk fibre the needles are not in the same vertical plane, will the combination be astatic? If not, how will it place itself, and why?

A.—The directing force acting on the combination is that due to the horizontal component of the earth's magnetic intensity at the place of the experiment. We have therefore only to consider the forces acting in a horizontal plane, which we will suppose to be the plane of the paper.



Let the vertical through the point of suspension cut the plane of the paper at O, and let N' S' and N'' S'' be the projections of the two needles on this plane. In order that the system may be in equilibrium, the sum of the moments about O of the force acting upon it must vanish, and, since the needles are equal and equally magnetised, it is clear that this condition will be satisfied when, and only when, the bisector of the vertically opposite angles N' O N'' and S' O S'' lies in the plane of the magnetic meridian.

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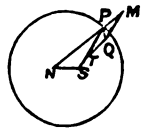
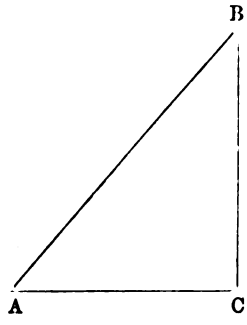
23. A bar magnet is laid at the middle of a circle on the floor. Explain a method by which the direction could be found, in which a small compass needle placed at any point on the circumference of the circle would set itself. (The earth's magnetic action may be neglected in comparison with that of the magnet.)



A.—Let N S be the bar magnet, and P the position of the centre of the small compass needle. Since the compass needle is very small in comparison with its distance from N S, we may consider the action of N S on the north pole of the needle to be the same as if the north pole were at the point P. The force exerted on the north pole of the compass needle by the north and south poles of N S respectively will be $\mu/N P^2$ acting in the direction N P, and $\mu/S P^2$ acting in the direction P S, where μ is a constant, its value being the product of the strength of a pole of N S into the strength of a pole of the compass needle. To determine the action of N S on the north pole of the compass needle we must therefore set off from P, along N P produced, a distance P M, representing on any convenient scale the quantity $\mu/N P^2$, and along P S we must set off a distance P T, representing on the same scale, the quantity $\mu/S P^2$. Completing the parallelogram T P M Q, and joining P Q, we find that the effect will be to make the needle set in the direction P Q, with its north pole pointing to Q. If we consider the action of N S upon the south pole of the needle, again assumed to coincide with P, we find in the same way that the effect would be to set the needle in the line P Q, with its south pole directed towards P, the same position as before.

24. Find the total magnetic force of the earth at a place where the horizontal component is 0·223 and the dip 60°.



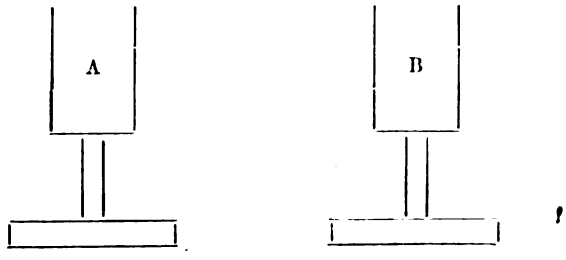
A.—Draw a straight line A C, representing on any scale the horizontal component of the earth's magnetic force; at the point C erect a perpendicular to A C, and through the point A draw the straight line A B, making an angle of 60° with D C, and cutting the perpendicular at B. Then A B represents on the same scale the total magnetic force.

But $$A B = \frac{A C}{\cos 60^\circ} = 2 A C$$

Therefore the total magnetic force is ·446.

Frictional Electricity.

25. You have two metal pots on separate insulating stands; also a metal ball carried by an insulating stem; also a wire connected with the earth. Suppose the ball, or one of the pots, to be slightly electrified. Describe and explain a process by the repetition of which you could electrify the two pots more and more strongly, one positively and the other negatively.



A.—Suppose we begin with a slight positive electrification on the ball.

(1) Hold the ball by its insulating handle within one of the pots, say B, without touching it. While it is there connect B to earth by means of the wire; then remove, first the wire and then the ball. B will thus receive a negative charge nearly equal in amount to the positive charge on the ball.

(2) Bring the ball, held as before by its insulating handle, into contact with the interior of the other pot A, then the charge on the ball will be transferred to A, leaving A positively charged and the ball neutral.

(3) Hold the ball near to the outside of A without touching it, earth-connect the ball, and remove the earth-connection while it is still under the inductive influence of A. The ball will then be charged negatively.

(4) Bring the negatively-charged ball into contact with the interior of B, when it will give the whole of its charge to B, leaving B with a stronger negative electrification.

(5) Hold the ball near to the outside of B without touching it, earth-connect the ball, and remove the earth-connection while it is still under the inductive influence of B. The ball will then be charged positively.

(6) Bring the positively charged ball into contact with the interior of A, when it will give the whole of its charge to A, leaving A with a stronger positive electrification.

By continuing this series of operations it is clear that the positive electrification of A and the negative electrification of B will be continually increased.

26. A large insulated metal ball at a great distance from all other conductors is electrified. And then by touching it with an earth-connected wire it is discharged. It is again electrified to the same degree as before, and then discharged by bringing it into contact with a wall of the room; why does the second discharge produce less heat than the first?

A.—The work done in discharging a conductor charged with a quantity, Q, of electricity, and at the potential V, is $\frac{1}{2}$ Q V.

The capacity of the conductor will have its smallest possible value, and therefore the potential will have its greatest possible value when the charged conductor is at so great a distance from all other conductors of electricity that no inductive action can take place between it and them. The potential of the metal ball will therefore diminish as it approaches the wall, since the latter is a conductor of electricity, while its charge remains unaltered.

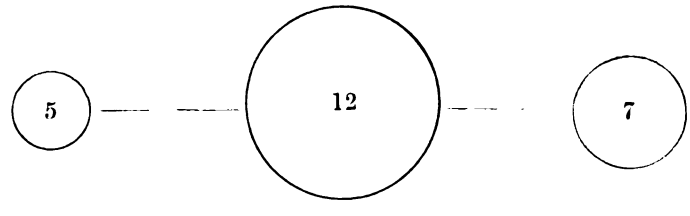
Less work will therefore be done in the direct discharge between the metal ball and the wall of the room than when the ball is kept at a distance from other conductors and discharged by contact with an earth-connected wire, the decrease in the potential of the ball, due to the neighbourhood of the wire, being exceedingly small compared with that due to the neighbourhood of the wall.

The same result may also be obtained directly from considerations of energy, thus:—

The electrified ball, at a great distance from the wall and all other conductors, possesses a certain definite amount of potential energy in virtue of its electrification.

As it is made to approach the wall it induces an opposite charge on the surface of the wall, causing an attraction between them, so that the ball in its approach does a certain amount of work, and, therefore, loses a portion of its stored up energy before the discharge takes place, and, therefore, there will be a smaller amount of potential energy to be transformed into heat during the discharge. The electrification induced on the wire when it is brought near to the ball will be so small that its effect will be practically inappreciable.

27. Three metal balls, the diameters of which are respectively 5, 7, 12in., are all connected together by very fine wires, but are otherwise insulated. If the smallest ball has a charge of 10, what are the charges of the other balls?



A.—If the spheres are so far apart that their inductive action on each other may be neglected, they may be considered as though each were at an infinite distance from all other conductors, as the presence of the fine wire will not increase their capacity by an appreciable amount. In this case, then, their capacities will be measured by their radii; and as they are electrically connected, and therefore at the same potential, their charges will be proportional to their capacities.

Therefore, if the 5in. sphere have a charge of 10, the 7in. sphere will have a change of

$$\frac{10 \times 7}{5} = 14$$

and the 12in. sphere will have a charge of

$$\frac{10 \times 12}{5} = 24.$$

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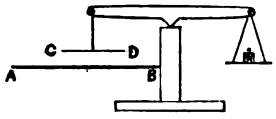
28. Describe and explain the use of any form of "attracted disc electrometer." Show what it measures, and explain the action of the "guard ring."



A.—The attracted disc electrometer consists essentially of a metallic disc A B, insulated and fixed in a horizontal position, and which can be maintained at a constant potential by being connected with the inside coating of a Leyden jar, or it may be kept at zero potential by being connected with the earth. Over the centre of this disc a smaller metallic disc, C D, is suspended horizontally from one end of the beam of a balance, the other end of which carries a weight, W.

The instrument is used to measure the difference between the potential of a conductor placed in metallic connection with C D, and that of the disc A B.

If the disc A B be made large compared with C D it may be treated as though it were an infinite plane; and in that case if V be the difference in the potentials of the discs, and the distance D between them be very small, we may neglect the effect of the electrification on the upper surface of C D, and the density σ on the lower surface will be $V/4\pi D$, and therefore if A be the area of the disc C D, and F the force between the two discs, we shall have

$$F = 2\pi\sigma^2 A = \frac{V^2 A}{8\pi D^2}$$

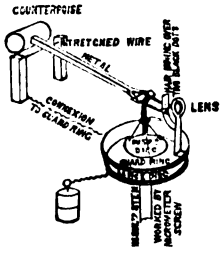
If W be the mass in the scale pan, and g the force of gravity at the place of observation, we shall also have

$$F = W g,$$

and therefore

$$V = D\sqrt{\frac{8\pi W g}{A}}$$

This formula is, however, only exact when D is infinitely small compared with the diameters of the discs, and, therefore, very small distances must be used to get approximately correct results, and it is then very difficult to measure D correctly and also to ensure that this distance should be nearly enough equal between different parts of the plates. Sir William Thomson, therefore, in addition to other improvements, has modified the instrument by the addition of the guard ring, which consists of a metallic disc, at least as large as the fixed disc, and having a central aperture through which the attracted disc can just pass without touching.



(From "Maxwell's Electricity," Vol. I., p. 267, 1st Edition.)

The guard ring has its lower surface truly plane, and is fixed so that it always remains parallel to the lower or fixed disc. The observations are made with the movable disc in the same plane as the guard ring, so that, as they are in electrical communication by means of the fine wire shown in the figure, they may be considered as forming one disc, but the force is only measured on that part of this disc where the distribution is most regular, the want of uniformity being almost entirely near the edge, and, therefore, of no importance, as it occurs on the guard ring and not on the suspended portion. Electrification of the back of the disc is entirely prevented by connecting the guard ring with a metal case surrounding the back of the suspended disc.

The fixed disc is mounted horizontally on an insulating stem, and can be moved vertically through measurable distances by means of a micrometer screw. The suspended disc is delicately balanced in the manner shown in the figure.

To adjust the suspended disc in the plane of the guard ring, the lower disc is screwed up until it comes into contract with the guard ring, and the suspended disc is allowed to rest upon the lower one, so that its under surface is in the same plane as the under surface of the guard ring. Two black dots are then made on an arm attached to the guard ring, and another branch of this arm carries a plano-convex lens, with its convex side next to the dots. A hair is attached to the movable disc in such a position that when it is in the right position with respect to the guard ring, the hair when viewed through the lens appears straight, and bisects the distance between the dots. The horizontality of the suspended disc is tested by comparing the reflection of part of an object from its upper surface with that of the rest of the same object from the upper surface of the guard ring.

The balance is so arranged that when the apparatus is entirely free from electrification (ensured by putting every part in metallic communication), and a certain known weight is placed on the centre of the suspended disc, it is in equilibrium in its normal position, determined as above.

A metal case provided with apertures through which the dots can be seen is placed over the guard ring, and encloses the balance and suspended disc. This case is in metallic communication with the guard ring and suspended disc, but is insulated from the other parts of the apparatus.

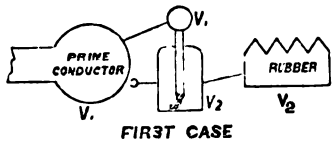
When the difference of potentials of two conductors is to be measured by the instrument, they are connected by means of fine wires to the upper and lower discs respectively, the weight on the suspended disc is removed, and the lower disc is moved up by the micrometer screw until the electrical attraction brings the suspended disc back to the normal position.

A mathematical investigation shows that if the suspended disc and guard ring are accurately in the same plane, and there is only a very small portion of the aperture unoccupied by the suspended disc, the difference of potential will again be given, to a very close approximation, by the formula

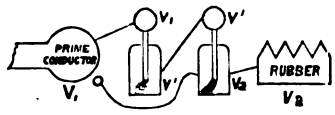
$$V = D\sqrt{\frac{8\pi W g}{A}}$$

where A is now to be taken as the mean between the area of the suspended disc, and that of the aperture in the guard ring.

29. The inside of a Leyden jar is connected with the prime conductor of an electrical machine, and the outside with the rubber of the machine, and also with a brass ball fixed at $\frac{1}{10}$ inch from the prime conductor. If the jar is at first without charge, ten turns of the machine are required to cause a spark to pass between the conductor and the ball. If now (the inside of the jar remaining, as before, connected with the prime conductor) the outside is insulated and connected with the inside of an exactly similar jar, the outside of which is connected with the rubber and the brass ball, show how many turns of the machine would be required to make a spark pass.



FIRST CASE



SECOND CASE.

A.—The same difference of potential must be produced in each case between the prime conductor and the rubber of the machine, and therefore the number of turns required in the two cases will be in the proportion of the capacity of the single jar to the capacity of the two jars arranged in "cascade." Let V_1 be the potential of the prime conductor, and therefore also that of the inner coating of the single jar in the first case, and of the inner coating of the first jar in the second case. Let V_2 be the potential of the rubber, and therefore also that of the outer coating of the single jar in the first case, and of the outer coating of the second jar in the second case. Let V^1 be the potential (in the second case) of the outer coating of the first jar, and therefore also of the inner coating of the second jar.

Then if A be the area of one coating of a jar, d the thickness, and k the specific inductive capacity of the glass, the charge of the single jar will be

$$Q = (V_1 - V_2)\frac{k A}{4\pi d}$$

and in the second case the charge of the first jar will be

$$Q_1 = (V_1 - V^1)\frac{k A}{4\pi d}$$

and the charge of the second jar will be

$$Q_2 = (V^1 - V_2)\frac{k A}{4\pi d}.$$

Hence

$$Q_1 + Q_2 = (V_1 - V_2)\frac{k A}{4\pi d} = Q.$$

So that the capacity of the two jars connected in cascade is $k A/4\pi d$, the same as that of a single jar.

Ten turns of the machine will therefore be required to cause a spark in the second case as in the first.

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Voltaic Electricity.

30. Two exactly equal pieces of copper are drawn into wire ; one into a wire 10ft. long, and the other into a wire 20ft. long. If the resistance of the shorter wire is 0·5 ohm, what is the resistance of the longer wire ?

A.—Since the two pieces of wire contain equal amounts of similar metal, therefore the second piece having double the length of the first will have half its sectional area, and therefore, since the resistance of a wire of a given material is proportional to the quotient of its length by its sectional area, the resistance of the second wire will be four times that of the first, or 2 ohms.

31. A thick copper wire and a thin copper wire, of such lengths as to have the same resistances, are joined end to end and used to connect the terminals of a battery, so that the same current flows through them both. Explain why the thin wire becomes hotter than the thick one.

A.—Since the resistances of the two wires are equal, and the same current flows through them, equal quantities of heat are produced in the wires.

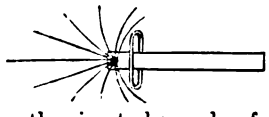
If we consider what happens when the current is first started we see that the thin wire will rise the more rapidly in temperature, for two reasons.

(1) The thin wire, having the same resistance as the thick one, must be shorter, as well as of smaller diameter, and therefore its mass must be less than that of the thick wire.

(2) The thin wire must, for the same reason, have a smaller superficial area than the thick one, and therefore the heat generated in it does not escape so rapidly by radiation.

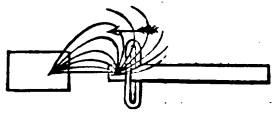
When a permanent state is reached the thick wire will remain at a lower temperature than the thin one, owing to its greater radiating surface.

32. A metal ring is put round the end of a bar magnet. Upon bringing a mass of soft iron near to this end of the magnet, a current is produced in the ring. Show what motions (*a*) of the magnet and (*b*) of the ring will produce a similar current in the absence of the soft iron.



A.—We will suppose the ring to be made of some non-magnetic metal, as the lines of force in that case are not affected by the ring, and therefore the figures will be simpler ; but it will easily be seen that a similar result would be obtained in either case.

Fig. 1 shows the ring surrounding one end of the bar magnet, with the general form and direction of the lines of force due to the pole near the ring. If a piece of soft iron be brought near to this end of the magnet it will be magnetised by the inductive action of the magnet, and will deflect the lines of force, making them cut the ring in the direction shown by the arrow in the second figure, causing a momentary current round the ring.



In order to produce a similar current in the absence of the iron by a motion of the ring relative to the magnet, the motion must be such that the lines of force will cut the ring in the same direction as before, and it is clear from the first figure that this will occur either when the ring is pushed further on to the magnet (towards its centre) or when the magnet is pushed further into the ring.

33. A battery is employed to drive a magneto-electric engine. Does the rate of consumption of zinc increase or decrease (and why) if the speed of the engine is increased by lessening the work it has to do ?

A.—If the speed of the engine be increased by lessening the work it has to do, the back electromotive force will be increased. This will diminish the current through the battery, and therefore the rate of consumption of zinc will decrease.

34. Six Grove cells, connected (*a*) in a single series and (*b*) as two series of three each, are used to decompose water in a voltameter. If there is no local action in the battery, show how much zinc is dissolved in each case (*a*) and (*b*) in the whole battery, while one grain of hydrogen is evolved in the voltameter.

Take sulphate of hydrogen (sulphuric acid) as H_2SO_4 (98) and sulphate of zinc as $ZnSO_4$ (161).

A.—Taking $H=1$ we get

$SO_4=98-2=96.$

And therefore $Zn=161-96=65.$

Now Zn replaces H_2, therefore for each grain of hydrogen evolved in the voltameter $65/2=32·5$ grains of zinc are dissolved in each cell connected in series. Thus

Quantity dissolved in first case $=32·5\times6=195$ grains.

Quantity dissolved in second case $=32·5\times3=97·5$ grains.

COMPANIES' MEETINGS & REPORTS.

Submarine Telegraph Company (Limited).

The half-yearly meeting of the proprietors of this Company was held at the offices, 2, Throgmorton-avenue, London-wall, on the 3rd inst., under the presidency of Sir Julian Goldsmid, Bart, M.P.

The SECRETARY (Mr. S. M. Clare) having read the notice convening the meeting, and the Chairman having affixed the seal to the register of shareholders, the report, which has appeared in *The Electrician*, was taken as read.

The CHAIRMAN, in moving the adoption of the report, said : I have very few observations to make. You will see that the diminution in the length of the messages has continued, and the result has been that we have received considerably less than we did during the corresponding period of 1885, and at the same time, owing to causes mentioned in the report, to which I shall refer a little presently, the expenditure has increased. Now, with regard to the length of the messages, it has been my practice for several years to give you complete information, in addition to what appears in the report, and I think you will immediately see, when I give you the figures to-day, why it is that we have received so much less. The report says that we carried 20,777 more messages in the six months which ended on the 30th June last than we did in the corresponding period of 1885. But we carried in those messages 747,315 words less. Now, of course, as we are paid by words you will understand that by the reduction in their number we have received so much less. In January, 1885, the average length of the messages was 11·80 words, and in the month of January, 1886, the average length was 11·10 words. That shows you a decrease of ·70 words for the month, and each month has gone on much in the same proportion. In February, 1885, the average length was 11·75 ; in February, 1886, it was 11·07 ; in March, 1885, 11·69 ; in March, 1886, 10·95 ; in April, 1885, 11·86 ; in April, 1886, 11 ; in May, 1885, 11·62 ; in May, 1886, 11·11 ; and in June, 1885, 11·57, against 11·08 in 1886. The total gives an average of 11·72 words for the six months ended June 30th, 1885, whereas the average length of the messages sent in the six months which have just ended was 11·05 words, showing a decrease of ·67 words. That decrease, therefore, clearly explains to you the diminution of the income in the half year. The next point is that we have some increase of expenditure. First of all, and most important, and most necessary, has been the increase of expenditure upon the cables. As you will remember, during the previous year or two we had been singularly fortunate as to accidents to the cables. We had very few, and the result was that we spent comparatively little on the cables. But the half year we are now referring to was less satisfactory. We had to put in a considerable amount of new cable in our repairs. We used £1,700 worth more cable in our repairs than we did in the previous half year. The increase altogether was £2,095—that is an increase to carry on our business. No sensible man—and I believe all proprietors in submarine telegraphs are sensible men—will object to that. The other item of increase is the salaries of the clerks. We have several classes of clerks, and the men gradually rise from one class to another. The two highest classes contain a fixed number, and at the present time there are of the second class that can be promoted to the first class only three clerks. The result is that we have, I trust, got nearly to the maximum of expenditure as to salaries. But it is right that the Company should give fair and reasonable salaries. The system adopted has cost the Company a good deal of money, however. The other amount of increased expenditure is the large payment to the French Government on account of the clerks on the other side of the water. At the former meeting I said there was some question raised by the French Government as to the payment on our part for clerks in Paris. We thought the claim on us was unreasonable, and we instructed our legal advisers to resist the claim. We were threatened with considerable law suits, and although we were advised that we should win, no sensible company likes to have a fight with a Government with whom it is carrying on business, and I saw a chance of a satisfactory settlement with the excellent man who is now the Minister of Posts and Telegraphs, and we came to an arrangement by which we have to pay a moderate increase, arriving at the same time at a final settlement of the matter. This arrangement was approved by the directors. It may cost us £1,000 or £1,200 a year more, but it puts us on a satisfactory footing with the French Government. Those are the items of increase, and you will see why they have occurred. Under the circumstances we are only able to pay you a dividend at the rate of 12 per cent. per annum. There are indications of the prospect of more business during the next six months than the last half year, and consequently I hope we shall be able to submit to you a better report. At the same time I have always tried since I was Chairman of the Company to put the exact state of affairs before you, and I think it is right that shareholders should know that as much as Directors. I have told you exactly how we stand, and I think that is all I have to tell you. I now move the adoption of the report and accounts.

The Hon. ASHLEY PONSONBY seconded the motion, which was carried unanimously.

The CHAIRMAN then moved the declaration of the dividend recommended, payable, less income-tax, on and after the 1st proximo.

The Right Hon. ROBT. BOURKE, M.P., seconded the motion, which was carried unanimously.

On the motion of the CHAIRMAN, seconded by Alderman Sir THOMAS DAKIN, the Hon. A. Ponsonby was re-elected to his seat at the Board, as was also the Hon. H. R. Brand, on the motion of the CHAIRMAN, seconded by Mr. HOLDSWORTH (a shareholder).

General HUTCHINSON next moved, and Mr. GIVENS seconded, the re-

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election as Directors of Mr. Wm. R. Cole and Alderman Sir Thomas Dakin, which was unanimously agreed to.

Mr. HOLDSWORTH proposed a vote of thanks to the Chairman and Directors. The Chairman, he said, had not been able to give them as satisfactory a statement as they could wish; but, on the whole, there were several elements of satisfaction in it. He gathered from what the Chairman had said that the tide had turned as regarded the diminution in the length of the messages. Another very satisfactory feature in the Chairman's statement was the fact that they would come to an amicable arrangement with the French Government as to the payment of the clerks. Nothing, he thought, could be more important than that they should be on thoroughly friendly terms with the French Government, especially taking into consideration what might happen in a very few years' time.

Alderman Sir THOMAS DAKIN seconded the motion, which was carried unanimously.

The CHAIRMAN: We are much obliged to you for the observations which have been made in such a friendly spirit by the mover of this resolution and for your continued confidence in the Board. The Directors, as heretofore, will endeavour heartily to do their best in the interests of the Company.

The proceedings then terminated.

Cuba Submarine Telegraph Company (Limited).

Report of the Directors for the half-year ending 30th June, 1886, to be presented to the shareholders at the thirtieth ordinary general meeting on the 11th inst., at 1 o'clock p.m. :—

From these it will be seen that the gross receipts (including the balance brought from last account) amount to £20,150. 17s. 4d., and the gross expenditure (including the half of the annual payment on account of the 1881 cable, and the expenses in connection with cable repairs), to £10,148. 19s. 8d., leaving a sum of £10,001. 17s. 8d. to the credit of revenue account. After providing for the preference dividend, a balance of £7,001. 17s. 8d. remains out of which the Directors recommend the payment of a dividend on the ordinary shares at the rate of 8 per cent. per annum, free of income-tax, which will absorb £6,400, and leave £601. 17s. 8d. to be carried forward to the current half-year's account. The Batabano-Cienfuegos (original) cable broke down on 28th March, and was repaired on 25th May. This cable not being duplicated, messages were forwarded during the interruption over the land lines of the Government. The repair was effected by Mr. Keith, the Company's engineer, who has also during the half-year laid a new harbour length at Santiago to replace one worn out. With regard to the proposed cable between Halifax (Nova Scotia), Bermuda, and Jamaica, referred to in the last report, the shareholders will be glad to learn that the British Government have decided not to lay a cable from Bermuda to Jamaica, but only from Halifax to Bermuda, thus avoiding the injury which this Company would have sustained had the project being carried out in its entirety. The director who retires from the Board at this time is Mr. Alexander F. Low, who, being eligible, offers himself for re-election. Mr. Thomas Greenwood, the auditor, also retires, and offers himself for re-election.

The National Telephone Company.

Report of the Directors for the year ending 30th June last, to be presented to the shareholders at the sixth annual ordinary general meeting of the Company, to be held at the offices of the Company, 11, Queen Victoria-street, on Friday, August 6th, 1886, at 3 o'clock p.m :—

The capital expenditure for the year, including the purchase of the system of the Dundee and District Telephone Company, Limited, has been £39,930. 7s. 7d., against £53,290. 17s. 1d. in the previous twelve months. The gross revenue allocated to the past year is £75,635. 5s. 8d., against £62,525. 18s. 6d. allocated to the previous year, and the amount carried forward to next year is £43,985. 18s. 6d., against £38,641. 13s. 10d. carried forward last year. The annual rentals on the 30th June reached £80,674. 2s. 8d., against £70,943. 11s. 3d. at the corresponding date of the previous year, showing an increase of £9,730. 11s. 5d. After providing for the accrued interest on the debentures, the dividend of 6 per cent. on the first preference shares, the dividend of 6 per cent. on the amount of second preference capital called up, and after having paid an interim dividend for the first half of the year at the rate of 3 per cent. per annum on the ordinary capital, there remains a balance of profit amounting to £10,822. 15s. 3d. Out of this the directors propose to allot a further sum of £7,875 to the payment of a dividend upon the ordinary capital for the second half of the year, at the rate of 3½ per cent. per annum, and, besides placing 2,000 to the reserve fund, to carry forward £947. 15s 3d. To the reserve fund of £5,000, which was taken last year out of the amount carried forward from the profits of that and previous years, the Directors propose to add, as indicated in the last paragraph, a further sum of £2,000, which will increase the reserve to £7,000. The Company has continued the erection of the trunk wires to connect different towns in various parts of its territory, as well as for the purpose of hereafter substituting those rented from the Postmaster-General in the Glasgow district. The Company has now 363 miles of trunk pole lines carrying 2,216 miles of wire. The revenue from annual renters is growing steadily, whilst that from free messages shows a rapid and regular monthly increase. During the past year the Company has opened telephonic exchanges in nine towns which did not previously possess the advantage of a telephonic system, and further development in the same direction is in progress. The United Telephone Company has again met with decisive success in the defence of its patents against infringers. The retiring directors are Messrs. William Hardwicke Bradbury, London, William Lowson, Dundee, and Samuel de la Grange Williams, Birmingham, who, being eligible, offer themselves for re-election. The auditors, Messrs. Quilter, Ball and Company, also retire, and are eligible for re-election.

South of England Telephone Company.

Report of the Directors for the fifteen months ended 30th April last, to be presented at the second ordinary meeting of shareholders, to be held at Winchester House, Old Broad-street, E.C., on Monday, August 9th, at 1 o'clock :—

Up to the 30th April, 1886, a sum of £11,849. 10s. 6d. has been expended on account of capital expenditure. The revenue account shows a gross revenue of £3,408. 14s. 10d., and a credit balance of £1,051. 5s. 7d., after payment of all charges, including a proportion of the preliminary and formation expenses. The dividends on the 6 per cent. preference shares, due October 31st, 1885, and April 30th, 1886, have been paid. Every effort has been made to push forward the business of this Company since its district was taken over from the United Telephone Company, with a result as shown by the following statement :—

	Exchange Subscribers.	Private Line Renters.
February 1st, 1885	116	123
April 30th, 1886	687	248
Increase	571	125

In addition to the telephone exchanges at Brighton, Norwich, and Ipswich, handed over to this Company by the United Telephone Company, exchanges have since been established at the following places, and further extensions will be made as the business develops :—

Bedford.	Gravesend.	Maidstone.
Cambridge.	Great Yarmouth.	Northampton.
Chatham.	Hastings & St. Leonards.	Oxford.
Eastbourne.	King's Lynn.	Peterborough.
Folkestone.	Luton.	Reading.

It is with extreme regret the Directors have to announce the death of the late Chairman, Mr. Robinson Kendal, on March 13th last. The vacant seat on the Board has been filled by the election of Mr. Alexander M'Gregor, of 3, Collingham-gardens, London, S.W., and Mr. David Owen Bateson has been elected Chairman. In conformity with the Articles of Association the following directors, Messrs. D. O. Bateson, T. F. Campbell, and A. M'Gregor, retire, and, being eligible, offer themselves for re-election. The shareholders' auditor, Mr. J. Weise, retires, and is eligible for re-election.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. AUG. 4.		BUSINESS DONE WEEK ENDING AUG. 4. Highest.	Lowest.
Anglo-American	32,	33	33	32
Do. Preferred	53,	54	54	—
Do. Deferred	10,	10½	10½	10⅜
Brazilian Submarine	10⅜,	10⅞	10⅞	—
Cuba	11,	11½	11½	11
Do. Preference	18½,	19½	—	—
Direct Spanish	1½,	2	—	—
Do. Preference	9,	10	—	—
Direct United States Cable	8¾,	9⅛	8 15-16	8⅞
Eastern Telegraph	10⅞,	11	11⅛	10⅞
Do. 6 per Cent. Preference	14½,	14½	14½	14
Do. 5 per Cent. Debentures, 1899	105,	108	—	—
Eastern Extension	12,	12¼	12 9-16	12⅛
German Union	9⅛,	9⅞	—	—
Globe Telegraph and Trust	6⅛,	6½	6⅝	6⅜
Do. Preference	13½,	13⅝	13 7-16	13 3-16
Great Northern	12½,	12⅝	12⅝	12 9-16
Indo-European	35½,	36½	—	—
Reuter's	6,	6½	—	—
Submarine	195,	205	199	—
West India and Panama	⅝,	¾	—	—
Do. 1st Preference	8⅞,	9⅛	9⅛	9
Western Brazilian	6¾,	7⅛	7 1-16	—
Western Union 7 per Cent. 1st Mortgage	118,	122	—	—
Do. 6 per Cent. Sterling Bonds	103,	107	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	13-16	15-16	—	—
Oriental	3-16	5-16	3-16	—
United Telephone	13⅜,	13⅝	13⅝	13⅜

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	2⅛,	2⅜	—	—
Do. (fully paid)	4,	4½	4½	—
Swan	1,	1⅛	—	—
Maxim-Weston	3-16	5-16	—	—

MISCELLANEOUS.

Telegraph Construction	37½	38½	39	37½
India Rubber, Gutta Percha, and Telegraph Works	22½	23½	23⅝	23½

TRAFFIC RECEIPTS FOR JULY, 1886.

COMPANIES.	July, 1886.	July, 1885.	Increase.	Decrease.
Cuba Submarine	2,800	2,517	283	—
Direct Spanish Telegraph	1,270	1,284	—	14
Eastern Extension	34,931	46,099	—	11,168
Eastern Telegraph	43,708	48,081	—	4,373
West Coast of America	3,050	—	—	—

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NOTES.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 6th inst. amounted to £3,167.

WEST AFRICAN CABLE.—The Silvertown Company has received a telegram from West Africa announcing the completion of the Accra-Grand Bassam section on the 28th ultimo.

ELECTRICITY AT THE ECOLE CENTRALE.—The subject of the theme set the pupils of the Ecole Centrale for the end of the scholastic year is "The utilisation of a waterfall equal to 300 horse-power for the public and private lighting of a town."

ADMIRALTY ORDERS.—We are informed that the Admiralty have recently placed a large order for switches, fusible plugs, brackets, and other electrical fittings in the hands of the Woodhouse and Rawson Electric Manufacturing Company.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 6th inst. were £2,476, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

ELECTRICAL EXHIBITION AT BERLIN.—The Berlin Edison Company are about to open a private exhibition in Berlin. It is expected that they will display a very interesting collection of apparatus illustrating the employment of electricity for domestic purposes.

THE TELEPHONE FOR RAILWAY SIGNALLING.—The stations upon the Valmordois (Aisne) line of railway have now been placed in communication by telephone. This is the first instance in which the telephone has been employed for railway signalling in France.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic receipts of this company for July were £23,000, and the receipts for the period from 1st January to the 31st July, £147,560; for the corresponding months in 1885 and 1884, £168,040 and £155,880 respectively.

CENTRAL STATION LIGHTING IN BRUSSELS.—It is stated that the Brussels Municipality have made a convention empowering a M. Helmer to lay underground wires throughout the city for electric lighting; but no details of the project have yet come to hand.

A CHURCH STRUCK BY LIGHTNING.—During a thunderstorm a few days since the church at Reminemont (Vosges) was struck by lightning, and suffered damage to the extent of 87,000fr. We regret to state that at the same time the relics of St. Romaric were entirely destroyed.

THE RECENT PATENT LAW DECISION.—We have received from Professor Silvanus Thompson a duplicate copy of a letter which he has sent to *The Times* in continuation of the correspondence upon the above subject. We are, of course, unable to insert it until *The Times* has had an opportunity of doing so.

EDISON.—Edison has stated that he is chiefly devoting his attention at present to methods for cheapening the production of electric lamps and carbons. It is to be hoped that he will attain a very complete success in this direction, and that the consumer will be permitted to enjoy a fair share of the benefit.

PROGRESS OF ELECTRIC LIGHTING IN AMERICA.—The American journals continue to record a rapid rate of progress of electric lighting in that country. New companies, new dynamos, new lamps, both arc and incandescent, new installations, both public and private, and the multiplication and enlargement of central lighting stations are continuously recorded.

BELGIAN ELECTRICIANS.—The Belgian Society of Electricians is to be fused with the Belgian Society of Engineers, who meet in the Brussels Bourse. This step will probably lead to a considerable accession of Belgian electricians to the ranks of the International Society of Electricians, whose head-quarters are at Paris. This body has now appointed M. Bandsept, of Brussels, as Belgian delegate.

PUBLIC LIGHTING IN PARIS.—There are at present only three public installations of the electric light in Paris, and neither of these is at all of an extensive character. The Place du Carrousel is lit by the system known in France under the name of Lontin de Mersanne. The Brush system is to be found in the Parc des Buttes-Chaumont, and Jablochkoff candles are still to be seen in the Parc Monceau.

MR. W. E. CASE'S "HEAT CELL."—Since the communication presented to the Royal Society by Mr. W. H. Preece, which we printed in our last issue, Mr. Case has written to the *Electrical World* stating that by the substitution of carbon for platinum as the negative element in his "heat cell," he has succeeded in obtaining an E.M.F. of 0·473 volt. This is very nearly double the value which was given by the former arrangement.

THE TELEPHONE AS A STREET FIRE ALARM.—A new system of public fire alarms has recently been erected in certain districts of Berlin. A telephone is enclosed within a suitable iron box, which is closed in front by a pane of glass. The instrument is connected with the nearest fire station. A notice forbids any one to break the glass in order to use the telephone unless they are able to inform the fire station of the exact locality of the fire.

TELEPHONE TROUBLES IN INDIANA, U.S.—All the poles and wires belonging to the Telephone Company in Evansville (Indiana) have been cut and pulled down by order of the City Council, the whole of the instruments being thereupon taken down and removed to Boston. This strong measure upon the part of the council is stated to be due to a refusal of the company to comply with certain ordinances concerning the working of the instruments issued by the civic authorities.

LODYGUINE'S INCANDESCENT LAMPS.—The lamps constructed by M. Lodyguine are said to be characterised by a remarkable toughness in the quality of the carbon. According to a recent statement the mechanical strength of the filament is "enormous." It is therefore possible to run these lamps at a very low expenditure of watts per candle-power, without unduly shortening their life. At the same time it is claimed that the extreme hardness of the carbon tends to prevent the blackening of the inside of the globes.

KEY WEST.—We are informed that the ss. "International," of the Silvertown Telegraph Company, sailed for Key West and Havannah on 11th inst. to renew the 1868 cable of the International Ocean Telegraph Company. This vessel should arrive at Key West about the 2nd prox., and will be joined there by Mr. M. L. Hellings, the cable manager of the American Company. Mr. Theophilus Smith goes out in charge of the work, and is accompanied by Mr. E. March Webb, the chief electrician of the Silvertown Company.

AN AMERICAN STORY.—A common result of too frequent applications of electricity is the paralysis of the affected parts. A quack in Portland, Oregon, has been professing to be a magnetic healer, and standing on plates connected with a concealed battery, he has been shooting the healing current through his patients by the laying on of hands. This wonderful healer has come to grief, not through the action of

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the Portland police, but through Nature's own action, for he has been paralysed by the continuous electrical action, and is now paying the penalty of his trickery.

EFFECTS OF LIGHTNING.—From *Nature* we learn that during a severe thunderstorm which passed over Central Norway last week a remarkable example of the power of lightning was witnessed. A fir tree 80ft. in height was struck by lightning, and a piece of the trunk 60ft. in length was torn off and thrown a distance of several yards. Strangely enough, the surface of the detached part is as smooth as if cut with a saw, while the stump remaining in the ground is jagged, charred, and splintered to the root. The ground around was torn up in all directions, one furrow being several feet in width and depth and 30ft. in length.

PORTUGUESE TELEGRAPHS.—Advices from Lisbon report an important reform in the Portuguese Public Works Department, which will have the effect of bringing the postal and telegraph services under the direct supervision of the Public Works Minister. Since the last reform of the telegraph service 64 new stations have been opened, and an increase of the *personnel* is required. It is therefore proposed to superannuate some of the old servants, and increase the total number of *employés*, with a view to improving the service, which is said to be in a very bad condition, and the cause of frequent complaints on the part of the public.

MILL LIGHTING BY ELECTRICITY.—Messrs. Platts are making use of electricity at their Quarry-street Mills, at Ashton-under-Lyne, for lighting purposes. The installation has been effected by the Manchester and District Edison Electric Light Company. The dynamo is of the Edison-Hopkinson type, and is capable of maintaining 400 sixteen candle-power incandescent lamps. It is driven from the main engine, and with the 320 lamps at present fitted absorbs about 36 horse-power. The lamps are Swan's, and are provided with white porcelain shades. The improvement is highly appreciated by the workpeople, and the temperature of the rooms is 15 to 20 degrees lower.

THE "VOLTA" PRIZE COMPETITION.—By a decree dated 11th June, 1882, the Government of France offered a reward of 50,000 francs for the discovery of greatest value relating to the utilisation of electricity for any of the following purposes:—As a source of heat, of light, or of chemical action; as a means of transmission of mechanical power, or of verbal communication in any form; or, finally, as a curative agent. The Minister of Instruction has now announced that June 30th, 1887, will be the latest date for entering the competition, and that the prize will be awarded in the following December. The competition is open to all, without restriction, and *savants* of all nations will be invited to participate in the award.

SERIOUS DAMAGE TO AN AMERICAN INSTALLATION.—From one of the American journals we take the following story:—A few days since a two-storied timber-built house was being moved through the streets of New Jersey City. All day long the Erie street horse cars were blockaded. On Friday night the labourers made their hauling tackle fast to one of the telegraph poles. The strain was so great that the pole leaned over, and several of the wires gave way, and fell upon the Electric Light Company's cables. Forty-one arc lamps in the principal streets were extinguished, and the insulation of the dynamos was seriously injured, besides other damage in the machine room. The owner of the house is threatened with a suit for damages.

TELEPHONIC COMMUNICATION BETWEEN BRISTOL AND BATH.—The Western Counties and South Wales Telephone Company have just completed the laying of a trunk wire between the cities of Bath and Bristol. The distance is only about fourteen miles, and therefore it need hardly be said that the results have proved thoroughly satisfactory. At present there is no telephonic exchange in Bath, although there are a number of private users of the telephone. It is expected that the facilities now offered for communication with Bristol will have the effect of largely increasing the list of subscribers in Bath, so that an exchange will probably be started at an early date. It is also in contemplation to lay down several more trunk wires connecting Bristol with adjacent towns and villages.

A NEW PRIMARY BATTERY DEVICE.—At the recent meeting of the International Society of Electricians a paper was read, describing an arrangement devised by M. Aboilard, by which the zinc plates of a primary battery may be lowered into or removed from the porous pots by mechanism actuated from any distance. The zincs are attached to a frame, which is suspended from a wooden support, and counterbalanced by weights placed upon the arm of a lever. A rod connected with this lever is moved in either direction by a clockwork attachment. The clockwork is released by means of an electro-magnetic catch placed in the circuit of an auxiliary Leclanché cell. By means of two separate pushes at the place from whence the battery is to be controlled, the zincs can be raised or lowered, as may be desired.

SPIRAL LIGHTNING.—During a severe thunderstorm which occurred on the 12th May in the present year, M. Ch. Moussette succeeded in obtaining several photographs of the lightning. In some of these the discharge has assumed the form of an irregular spiral. In the case of two flashes which were taken upon the same plate, the first is a dextrorsal spiral, and the second divides into two branches, for which the direction of rotation is different, one being right-handed and the other left-handed. The distance between the separate turns of these spirals varies greatly in different portions of the same discharge. It has been suggested that flashes of this character are probably due to the discharge of globular lightning having a gyratory motion, similar to the effects obtained upon a smaller scale by M. Planté.

ELECTRIC TRAMWAY AT HAMBURG.—An electric tramway has just been completed at Hamburg. The accumulator system has been adopted. Each car is capable of conveying thirty-three passengers, and weighs when fully loaded about 4,830 kilogrammes, the weight of the accumulators alone being 1,200 kilogrammes. The battery consists of 96 cells, each containing seven positive and eight negative plates. They are charged by means of two "Schwerd" dynamo machines, driven by an engine of 10 horse-power. The motors are of the Siemens type. Their speed is regulated by a switch, which alters the grouping of the battery cells. The cars are able to run about 50 kilometres with a single charge. The normal current on the level is 10 amperes, but it is sometimes as high as 80 amperes when mounting the steepest gradients.

THE ELECTRIC LIGHT AT A SHORTHAND SCHOOL.—Since the beginning of the present year the Metropolitan School of Shorthand has been lit by the electric light. The installation, which consists of fifty-eight incandescent lamps, conveniently distributed throughout the various passages and class rooms, and one arc light in the doorway, was put up by the Pilsen-Joel Company. The dynamo is driven by a 6 horse-power Otto gas engine in the basement of the building. Each pair of lamps in the class rooms is provided with a separate switch. Of course, it is not to be expected that so small an installation, independently worked—the fixed charges being quite as great

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as those for an installation two or three times the size—will be found to show any economical advantage, but the benefits resulting from its introduction in the matter of coolness and luminosity are highly appreciated by the students, and has undoubtedly led to their more rapid progress in stenography.

THE ELECTRIC LIGHT FROM A SANITARY POINT OF VIEW.—M. Gariel has recently published in the *Revue Scientifique* a paper of considerable length upon the sanitary aspects of artificial lighting in general. He treats the subject in three divisions—the use of (1) solids, (2) of liquids, (3) of gases, as illuminating agents. The first head is again subdivided into (1) those solid bodies which undergo chemical alteration—that is those which are burnt; (2) those which are heated by the combustion of another substance, but do not themselves undergo any chemical change; (3) those which yield a light without the necessity of any chemical action whatever taking place. M. Gariel concludes that the only method of the artificial lighting which can be considered thoroughly satisfactory from a hygienic point of view is one which fulfills the last-named conditions. He concludes his paper by a very strongly-worded commendation of the incandescent electric light.

BLOWING UP A SHARK.—The following sailor's yarn is now in course of circulation :—"We were lying off Natal the other day when a most exciting occurrence happened. We saw two or three monster sharks playing round the ship for some time—the largest of them measuring about 14 feet long—so we baited a line with a small piece of pork and dropped it out to him. He calmly swallowed the bait, hook and all, and cut the line with his teeth, taking no further notice of it. We then had recourse to strategy. The breast of a buck, which had been hanging up some time and was rather high, was weighted, in order to sink it, and a hand-charge of guncotton inserted therein, the whole being connected by wire with a boat's battery. No sooner had the venison reached the water than the shark made straight for it; but just as he opened his mouth to swallow the bait the charge was exploded, his jaws being completely shattered. The monster turned on its back and sank in the bay."

WHITWORTH SCHOLARSHIPS.—Twenty-five of these scholarships are awarded annually, one of £200, eight of £150, and sixteen of £100. The following are the successful competitors for 1886 :—G. C. Humphrey, Nottingham; R. Holt, Liverpool; R. Chorley, Manchester; J. H. A. M'Intyre, Glasgow; W. C. Borrowman, Glasgow; T. R. Murray, Galashiels (formerly Stafford); J. T. Nicholson, Newcastle-on-Tyne; G. M. Wooliscroft, London (formerly Crewe); J. Brown, Glasgow; R. Wallis, Newcastle-on-Tyne; R. M. Ferrier, Ardrossan; R. B. Creah, Crewe; E. Wilson, Leeds; E. S. Padmore, Birmingham; W. H. Watkinson, Glasgow; R. Johnstone, London; J. M. Malcomson, Woolwich; H. Shoosmith, London; E. Codling, Newcastle-on-Tyne; C. Day, Stockport; C. Hyde, Ebbw Vale; A. Etchells, Hyde; W. Berry, Glasgow; D. Kemp, Glasgow; G. H. Follows, Manchester. The students of the College of Science and Arts, Glasgow, have achieved a remarkable success, no fewer than six scholarships having been gained by them.

AURORA.—During the last few weeks many people have been remarking the very beautiful effects which have been visible above the N.W. horizon shortly after sunset. These appearances have taken the form of luminous clouds of a silvery blue lustre, and apparently floating at a very great elevation. Professor Piazzi Smith has written to *Nature* describing the results of a spectroscopic investigation of these clouds which he made upon the evening of the 27th ult. He found that the aurora line was distinctly present at different places upon or near the horizon. At this time there was a faint red glow in the west, at a higher elevation some stars were visible, and passing almost immediately overhead a long white streamer—apparently of cirrus cloud—trailed half across the sky. In the spectroscope this white streamer gave the aurora line with great distinctness, and only a very faint continuous spectrum in addition. Towards one in the morning a very beautiful display of auroral scintillations took place, and after this the whole display died out in a very few minutes.

CUBAN STORMS.—Father Vines, of the Royal College of the Society of Jesus, at Havana, and compiler of the "Meteorological Annual," for 1885, which has only lately been published, gives some interesting particulars as to the characteristics of thunderstorms in Cuba compared with those in the United States, which suggest that this line of inquiry is likely to lead to valuable additions to our knowledge of weather changes. For four days previous to the observation of the highest temperature of the year—July 30, at 4 p.m., 98·8deg. —auroras had been observed in the United States, and the magnetic and electrical conditions showed marked disturbances at Havana. Of eighty recorded thunderstorms sixty-five occurred during the five months from May to September, and only three during the four months from January to March and December. This almost total absence of thunderstorms from the rains of the winter months as compared with the summer months, when lightning or some other electric phenomenon occurs almost daily, is important in its bearing on the theory of the thunderstorm.

AN ABSTRACT ON SECONDARY ELECTROLYSIS.—E. Semmola, in the *Journal* of the Chemical Society, says : "If a small ribbon of platinum is immersed in a voltameter containing acidulated water, in such a way that its ends are opposite the electrodes of the voltameter, and a powerful current is passed through the latter, hydrogen and oxygen are evolved not only from the electrodes, but also from the ribbon. This secondary electrolysis varies greatly with different conditions, and ceases altogether when the current is not strong, but if oxidisable metals are used instead of platinum it becomes much more energetic. The phenomena are well seen with amalgamated zinc, which is not attacked by acidulated water except when the current passes. When the circuit containing the voltameter is closed, hydrogen is given off from one half only (the negative half) of the zinc, whilst oxygen is absorbed by the other half. If several pieces of zinc are immersed in the water in the voltameter, hydrogen is given off from each of them. This secondary electrolysis is due to a current derived from the immersed zinc."

LONG DISTANCE TELEPHONING.—The American Telephone and Telegraph Company of New York has recently been organised for the purpose of establishing direct telephonic communication between the large cities of the country. The first line has been constructed between New York and Philadelphia, the length of the route adopted being about 100 miles. Four years ago a similar attempt was made to connect New York and Boston, but the iron wire erected between the two cities did not prove successful. The present company has employed hard drawn copper wires, and now has seventy-four of them running the whole distance. The line is entirely aërial, except where waters of some width are crossed, in which case submarine cables are employed. Between the two cities there are six series of cables, the longest stretches being under the Hudson and Delaware rivers. The cables terminate at the foot of Vessey-street in New York, and near the foot of Walnut-street in Philadelphia. The line will probably be open

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for business within a few weeks, and it is expected that it will prove a great convenience.

THE "PARTZ" ACID GRAVITY BATTERY.—This battery has been designed with the intention of applying the principle of gravity for the separation of the solution in cells of the Bunsen type, in the same way as was done by Meidenger, Minotti, and others, for the Daniel cell. The Bunsen battery would, undoubtedly, meet with a much more frequent use at least for laboratory purposes, but for the trouble of having to set up the cell afresh every time it is required. In the "Partz" cell an acidified solution of an alkaline chloride or sulphate, is poured into the cell until it just covers the zinc plate, which is suspended from the rim of the vessel. A plate of carbon lies upon the bottom, and a special "depolarisation salt" is dropped upon its surface through a glass tube. This salt is formed by the action of sulphuric acid upon chromic acid. By this means the carbon plate is soon covered with a saturated layer of the depolarisating solution, which can at any time be renewed by merely dropping fresh pieces of the salt through the glass tube. The electromotive force is said to be 1·95 volt, and the internal resistance is relatively low.

LECLANCHÉ CELLS FOR LARGE CURRENTS.—An American manufacturer has introduced some modifications in the Leclanché cell, which would seem for certain purposes to be valuable improvements. Instead of employing either a porous pot or the "agglomerated" carbon, the inventor constructs the inner vessel of a very porous carbon. It is then filled with manganese and broken carbon in the usual way. The exterior surface of the vessel is rendered as large as possible by a series of projecting ribs. In this way the internal resistance of the cell is so much reduced that a battery of this construction is said to be capable of yielding a current sufficiently large for use in electric lighting. We imagine, however, that the E.M.F. must fall off at the same rate as it does in all other cells of the Leclanché type, and, if so, the electric lighting could only be of an intermittent character. On this point we are disposed to make a suggestion for the benefit of the inventor. Why not take two or more batteries, each capable of supplying the required current, and place in the circuit an automatic switch, which would switch in another set of cells as soon as the E.M.F. of the one in use had fallen below the required standard? We need not enter into details, but the idea may be taken for what it is worth.

ELECTRICITY AT THE WALTHAM POWDER FACTORIES.—A somewhat novel arrangement has recently been adopted for lighting the outlying sheds and warehouses of the Royal Gunpowder Factories at Waltham. The principal part of these works has been lit by electricity for some considerable time, but many of the storehouses, which are situated at a considerable distance from the dynamo room, have not hitherto been lit. But since each of these buildings stands upon the banks of one of the numerous canals by which the works are intersected, the superintendent, Colonel W. H. Noble, R.A., has devised a very simple and effective plan for lighting them when required. A small boat, 25ft. in length, has been built, capable of carrying about 30 of the E.P.S. cells (type 238), and is fitted with an electric motor and screw for its propulsion. When any of the buildings referred to are required to be visited at night, the boat moves up to the spot, and the batteries are then connected to the permanent installation of glow lamps with which each building is fitted. In this way the work of loading or unloading barges at night is very readily carried on. The electrical details were designed by Mr. T. Webb, the chief engineer of the works. The boat has been christened "The Spark," and has, so far, given every satisfaction.

POLARITY OF TADPOLES.—The following letter, by Dr. Leonard, on this subject has appeared in the *Scientific American*:—"In your issue of July 3 I notice a short paragraph on the 'The Polarity of Tadpoles,' which states that when a current was passed into the dish containing them (the poles of the battery being immersed in the water), all of them without exception took up 'one position, that in which the head was turned to the anode and the tail to the cathode.' I see nothing really surprising in this, and certainly nothing that would prove 'polarity' in the tadpole. The 'shock' from the cathode is always a great deal stronger than from the anode; also, the head of the tadpole (as in all animals) is the more sensitive portion of the body, electrically; hence the cathode presented to the head, if the current be strong, becomes quite powerful, whereas, if presented to the feet or tail, the current is much less severely felt. The arrangement of the tadpoles with their tails to the cathode is the position they should assume in order to reduce to a minimum the unpleasant sensation of the passage of the electrical current through their bodies. Confine a man in such a way that the current from a battery must pass through his body from head to foot, and he would very soon arrange himself with his feet to the cathode and his head to the anode, and yet this would be far from proving 'polarity' in the human body. There may be 'polarity' existing in the tadpole, but a different experiment than that made by Prof. Herman is necessary to prove it to me."

ELECTRIC TIMING OF BICYCLE RACES.—E. H. Foote, of the Massachusett's Bicycle Club, has submitted to President Ducker a scheme for obtaining absolutely correct timing of races, and it is so ingenious that the club will put it into practice. Take a strip of rubber 2½ to 3in. wide and 1-16th of an inch thick, long enough to cross the track. Sew or rivet on one side of this two strips of thin sheet brass or copper. Fold the two sides of the strips together. Fasten one end to the ground on the side next the stand. This end to be attached to a block of wood or rubber having binding screws connected with the metal strips. The screws are also connected in circuit with a battery and a loud single stroke bell. The strips are kept apart at the opposite end by a wooden plug if necessary. The riders to be started with their wheels just in contact with the strips. Whenever there is pressure enough put on the rubber to bring the metal strips in contact the bell will sound. The starting time to be taken at the first stroke of the bell when the first man crosses, as there would be a slight variation in the men getting away, and the rear wheels would also cause a stroke. The time of finish to be also taken by stroke of the bell. The time between the strokes of the bell would be absolutely correct, and could probably be taken more accurately than by the eye. This system could be extended by putting in the battery circuit a recording instrument, which would automatically and accurately record on paper each and every time, however many men there might be in the race. This would necessitate additional expense, as the recorder would have to be actuated by an accurate timepiece.

EXPERIENCE WITH A CHLORINE BATTERY.—Mr. J. W. King has written to the *English Mechanic*, giving an account of his experience with an "Upward" battery of his own construction. Everything being ready, and the cells (four in number) fully charged, the current was switched on to a 5 candle-power lamp, which it raised to a bright red heat. "Just then," Mr. King proceeds, "a leakage occurred in the generator, and in

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endeavouring to stop it up with clay I got nearly choked, and although the whole apparatus was in a shed nearly open, built outside the house, the gas got into the house, and caused great inconvenience. With great difficulty I filled the generator with cold water, thinking to stop the production of the gas, and left the whole concern to itself. Since then, without touching the batteries, I have taken every night a current from them, on the eighth night about one ampere, measured by one of Ayrton and Perry's instruments, which was not available for use before that." Mr. King, notwithstanding this distressing experience, considers the battery to be a first rate one, and that if only sundry objections could be overcome it would be without an equal. The difficulties which he considers require to be removed he summarises as follows:—"The first is some method of discovering any leakage in the apparatus. You can easily tell when there is a leak, but the thing is to find out where, and while you are doing that you are getting choked. The next thing is to be able easily to stop the production of the gas, as in the case of accident to any portion of the apparatus the gas continues to escape as fast as generated; and the third point is to find some easy method of absorbing the gas already generated and rendering it harmless in the case of accident." Mr. King concludes that until this has been done the battery is not adapted for use in the hands of unskilled persons. With regard to Mr. King's second and third points, we may state that a strong solution of hydrogen sulphide poured into the generator would speedily stop the evolution of chloride, and the same solution if heated in the apartment where the chlorine has escaped will render the gas practically innocuous; but hydrogen sulphide itself possesses so objectionable an odour that it is a question whether the remedy is not nearly as bad as the disease.

The Magnetic Survey of France.—M. Mascart has just completed the reduction of the observations which were taken under his supervision during the years 1884-5 for the construction of a new magnetic chart for the whole of France. The observation of the magnetic elements was carried out at 78 different stations in various parts of the country. Each station was carefully selected so as to avoid, as far as possible, any local disturbance which might arise from purely artificial causes, such as the neighbourhood of railways, factories, &c. The apparatus employed was specially constructed for the purpose by MM. Bruner, and consisted simply of carefully mounted declination and inclination magnets. The azimuth of the magnetic meridian was determined by taking the mean value deduced from the readings in several different positions of the compass. The horizontal component was obtained by counting the number of oscillations, after having determined the magnetic moment of the needle by the method of Gauss. The inclination was read directly from the needle when placed in the magnetic meridian. By comparison with the curves of annual and secular variation recorded by the magnetometer at the Observatory of Parc Saint-Maur all the observations have been reduced so as to be correct for the 1st January, 1885. The following are some of the most noteworthy results obtained:—The declination is a minimum at Belfort (13°·59′) and a maximum at Conquet (19°·25′). In the North of France it varies about 30′ for each degree of longitude; in the south the variation is smaller. Since the last survey by Lamonte, in 1854, the declination has diminished 3°·58′ in the north, and only 3°·19′ in the south. The mean annual variation of declination during this period has been 6·5′ at Nice, 7·4′ at Paris, and 7·7′ at Lille. It results from this that the lines of equal declination are at present gradually becoming parallel with those of the geographical meridians. Turning next to the value of the horizontal component, we find that the minimum value (0·18460 absolute units) was observed at Dunkerque, and the maximum (0·22124) at Perpignan. These curves are very nearly perpendicular to those of the magnetic meridian. The decrease of this element per degree of latitude proceeds more rapidly in the south than in the north. Since Lamont's observations in 1848 the mean value of the horizontal component has increased about 0·05. The annual variation is greatest in the west and slightly less in the east. Its mean value is about +0·00025. These lines are approaching the direction of the geographical parallels. The isoclinal lines have sensibly the same orientation. Since 1848 the inclination has diminished by 1°35′ in the north of France, and by 2° in the south. The annual variation is least at Belfort in the north-east (2′·6) and greatest in the extreme south (3′·4). These lines are also approximating to the geographical parallels.

Electric Lighting in a Calico Factory.—The Gülcher Electric Light Company have just completed the lighting of the calico print works of Messrs. J. H. Gartside and Co., Bucktonvale Works, near Stalybridge. The light has, in the first instance, been installed in the printing department, and it will be further extended to the other departments, dye and washing, &c., when the alterations are sufficiently advanced to permit of this being done. The lamps are arranged as follows:—1st, printing room, consisting of twelve printing machines, six 20 candle-power lamps, distributed to each machine; 2nd, printing room or shed, consisting of three machines, eighteen 20 candle-power lamps. The foreman's office and colour room, the manager's office, and the laboratory are also lighted. The 102 lamps used are of the Swan-Edison type, of sixty volts, and are driven from a No. 4 Gülcher dynamo, compound wound or self-regulating, of their latest and improved type. The machine is able to supply more than double the present number of lights. The motive power for drawing the dynamo is taken from the main driving shaft of the engine driving the hot air fans in use for the printing machines. A belt from this shaft drives a counter shaft fitted with fast and loose pulley with striking gear, from which a horizontal belt drives the dynamo. The current from dynamos goes to a circular switch, and is then split into three circuits so arranged that an equal number of lamps are in each circuit. Separate switches are fitted to every six lights, and wherever required to individual lights. Each switch is fitted with cut outs, in addition to the main cut outs at dynamo. The main leads are run in casing suspended by stout iron clips from the existing gas mains, which run over the printing machines. The branch leads are run to a switch-board placed conveniently for use in front of each printing machine, the tapping wires from same being run along the gas pipes to the individual lights. The lamps are all fitted with white opal shades, or reflectors, so that the utmost efficiency is obtained by directing the light on the work. This is found of great advantage in this installation owing to the variety of colours used in the work done. The lamps in the printing sheds are fixed to the existing gas fittings by strong brass clips to which is attached the holder, of Woodhouse and Rawson pattern, to carry the lamps and shades. One lamp to each printing machine is made portable, to allow the printer to set his rollers, &c. This lamp is placed in a circular brass guard, with a mahogany handle through which the flexible wire runs to the lamp. Bronze brackets are used in the offices and laboratory, each fitted with separate switch, with white opal reflectors. Great satisfaction is expressed by all interested in the use of the light, and no doubt in the future it will be extended over the entire premises.

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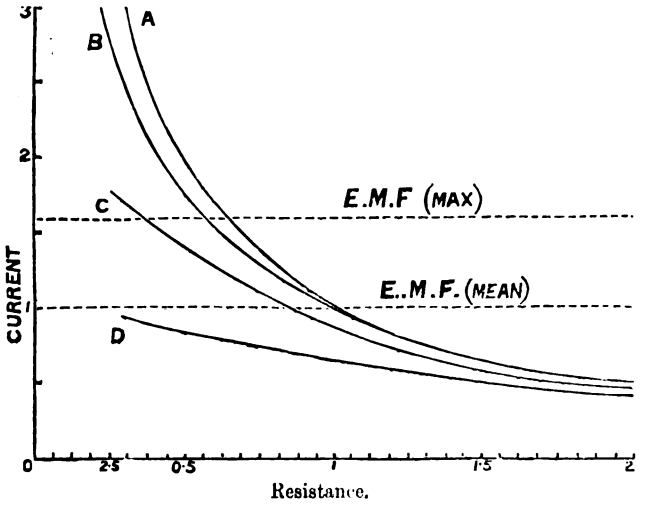
ALTERNATING AND INDUCED ELECTROMOTIVE FORCES.—IV.

BY W. H. SNELL.

In the last paper it was shown that the quantity of electricity conveyed by an alternating current is measured by $I \times 0{\cdot}637$, where I is the maximum periodic value of the current. In Fig. 7 resistance from zero up to 2 ohms is taken upon the axis X and values of current upon the axis Y. If the horizontal line along the unit ordinate be taken to represent the value of a *continuous* electromotive force acting in the circuit, then, as is well known, the current curve becomes a rectangular hyperbola, of which curve A will be the portion within the limits of the figure.

FIG. 7.



Now, let the same horizontal line represent the *true mean value* of an alternating electromotive force acting in the same circuit. Then the maximum periodic value of E will be represented by the horizontal line, which is drawn upon the ordinate $\frac{1}{0{\cdot}637} = 1{\cdot}49$. If, in the first place, these lines refer to *resultant* electromotive force, then the *true mean value* of the alternating current will be represented by the same curve as the continuous current, and the values of I will be at all points equal to 1·49 times the ordinates of curve A.

Next, suppose that the horizontal lines refer to *impressed* instead of to resultant electromotive force. Then, if there were no self-induction, curve A would still represent the current. Now, let us introduce a coefficient of self-induction such that $L = \frac{1}{4} N$; we shall therefore get a smaller resultant current, and this will be represented by curve B. Comparing A and B, it will be noticed that when the resistances are comparatively large the two curves are indistinguishable upon the scale of the diagram. Hence, at this time, the current is almost independent of the coefficient of self-induction if the latter be not very great in comparison with N. But as the resistance is reduced a point is reached when the current begins to diminish rapidly in the circuit containing self-induction, until at length the difference between the two currents becomes almost constant, and this difference is very nearly independent of the resistance.

The effect of increasing the value of L may be traced in curves C and D, for which $L = \frac{1}{2} N$, and $L = N$ respectively.

The case in which R is made constant at unit value, and the periodic time becomes subject to variation, may be illustrated by means of the same figure, R being now made always equal to unity; we may take the scale of abscissæ to represent *relative* values of T. The impressed electromotive force will then be given by the hyperbolic curve A, and if the values of L are made successively equal to 0, $\frac{1}{4}$ N, $\frac{1}{2}$ N, and N, then A, B, C, D will represent the respective currents. The curves will in this case represent either the true mean or the maximum values of the currents, according to whether A has been taken, in the first place, either for the mean or for the maximum periodic value of the electromotive force.

The case in which N varies does not require any special notice, for it is obvious that the result is merely to vary the vertical scale of the curve in direct proportion to the value of N.

There remains one more case which might easily be illustrated in the same way—that, namely, in which the variations of I are plotted with L constant and with successive values of R and T. This corresponds very approximately to the case in which an alternating machine is used upon an electric lighting circuit and the number of lamps is varied, while the machine is also run at different speeds. But in this case we should not be much interested in the current curves; it is the number of watts in the circuit that would be important. In order to save space we shall therefore omit this set of curves.

We will now proceed to consider in detail the rate at which work is done in any given circuit by an alternating current. It has already been shown that the continuous current which will do work at the same rate is equal to $I \times 0{\cdot}707$. The number of watts in the circuit will therefore be given by the equation,

$$W = (0{\cdot}707\, I)^2 R$$
$$= 0{\cdot}5\, I^2 R.$$

Substituting the value of I from (10) we have

$$W = \frac{1}{2}\left(\frac{2\pi N}{T}\right)^2 \left\{\frac{\sin^2(\theta - \phi)}{\left(\frac{2\pi L}{T}\right)^2 + R^2}\right\} \cdot R$$

but as the maximum value of the sine is unity, this reduces to

$$W = \frac{2\pi^2 N^2 R}{4\pi^2 L^2 + R^2 T^2} \qquad (13)$$

It therefore appears that the work done in unit time in a circuit of given resistance is increased either when L is diminished or, as might be expected, when the speed is increased. But if L and T are constant, then there will be a certain value of R, for which the number of watts becomes a maximum. This value of R may be found in the usual way by forming the equation

$$\frac{dW}{dR} = 0$$

and solving for R. We thus obtain

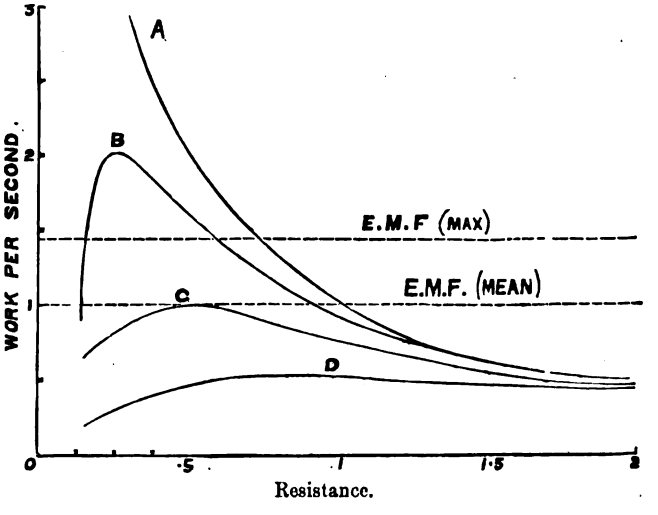
$$R = \frac{2\pi L}{T} \qquad (14)$$

as the condition under which W is a maximum. Now, we already know that the tangent of the angle of retardation is expressed by $\frac{2\pi L}{RT}$. Consequently (14) may be written

$$R = R \tan \phi.$$

Hence $\tan \phi$ must be equal to unity, and therefore ϕ is an angle of 45°. We thus learn that when a given alternating current does work at its maximum possible rate the angle of retardation will always be 45°.

FIG. 8.



In Fig. 8 resistance is taken along axis X and watts upon axis Y. Following the same method as in Fig. 7, we sup-

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pose, in the first place, that the horizontal line upon the unit ordinate represents a *continuous* electromotive force. The expression for the rate of work will be

$$W = \frac{E^2}{R}.$$

This is the equation to curve A, and as E has been made equal to unity, we obtain the same curve as A in Fig. (7).

Now, let the horizontal lines upon the unit ordinate represent the *mean* value of an alternating electromotive force. If this be taken as a *resultant* E.M.F., such that its maximum periodic value is drawn upon the ordinate $\frac{1}{0\,707} = 1{\cdot}414$, then the same work will be done in the circuit in a given time, either by the continuous or by the alternating electromotive forces, so that curve A again gives the number of watts produced.

Next, let the two horizontal lines refer to *impressed* instead of to resultant electromotive forces. The remaining curves are then drawn to equation (13), under the condition that T is constant, and L has the successive values given below. The column headed R gives the resistance for which the number of watts is a maximum in each case.

Curve	L.	R.
A	0	0
B	0·25 N	0·25
C	0·5 N	0·5
D	0 N	1·0

It is of course apparent that as the resistance increases from zero, the work done in unit time by a continuous electromotive force of constant value continuously *decreases*. And it will also be seen that the same thing holds good when the electromotive force becomes alternating, provided that there is no self-induction to the circuit. If, however, the circuit possess a coefficient of self-induction, then up to the point of inflexion of the curve the watts *increase* with the resistance; and the rate of increase is the more rapid as the value of L is *smaller*.

After passing through what may in this connection be termed the "critical value" of R, the watts decrease when the resistance rises, as they would do if the current were continuous. However large the value of L may be, if R is continuously increased we at length arrive at a point where the number of watts produced when the *impressed* E.M.F. has a constant mean value is practically the same as if the current were continuous, and the effect of self-induction has thus well nigh disappeared.

Fig. 9.

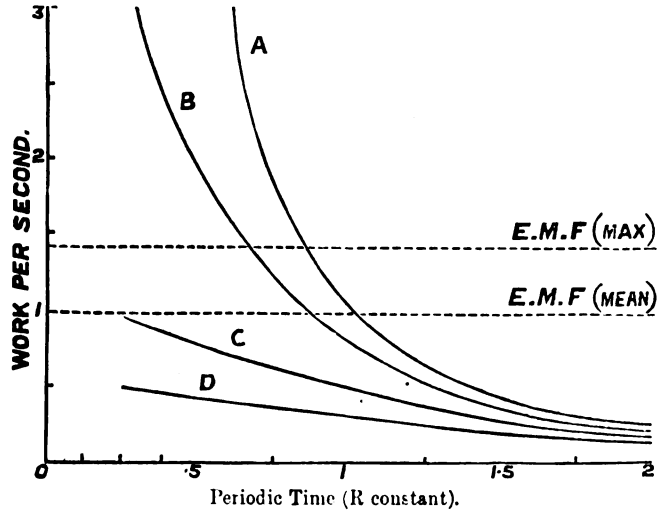
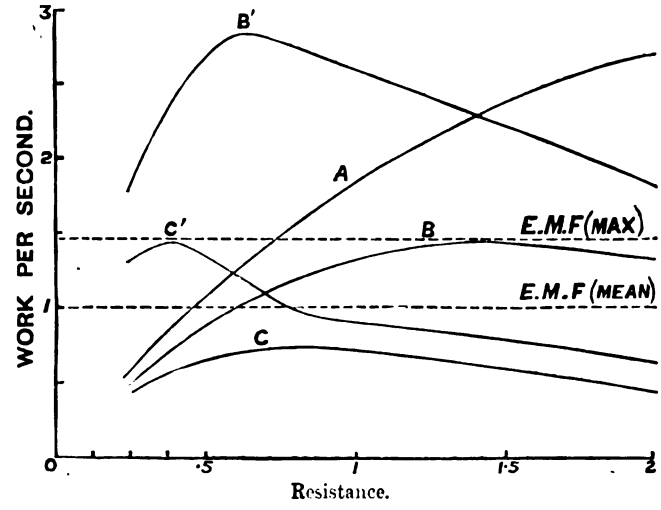


Fig. 9 illustrates the variation of W under the condition that R remains constant at unit value, while the self-induction and the periodic time undergo variation. R being constant there is no critical point in these curves. The relative values of T are taken along axis X, and the values of L are as follows:

Curve	L	Curve	L
A	0	C	½ N
B	¼ N	D	N

The lines of electromotive force are drawn only for the case when T is put equal to unity; in the other cases they would lie upon the ordinates equal to $\frac{1}{T}$. With this exception the figure may be examined in the same way as in the preceding case; taking the lower line of E.M.F. to refer in the first instance to a *continuous*, next to a *resultant*, and lastly to an impressed electromotive force.

Fig. 10.



Finally, Fig. 10 illustrates the variation of W with the periodic time and the resistance. It thus closely corresponds to the case of an alternating current machine, with a constant field, running at different speeds, upon an electric lighting circuit in which the number of lamps is varied. Two sets of curves are given for different values of L, as shown in the following table. As before, the column headed R gives the resistance which makes W a maximum:—

Curve.	T.	L.	R.
A	¼	½ N	2·83
B	½	½ N	1·414
C	1	½ N	0·707
B′	½	¼ N	0·707
C′	1	¼ N	1·414

The curve for $T = \frac{1}{4}$, $L = \frac{1}{4}$ N, would lie almost entirely beyond the limits of the figure.

In this figure there is no curve corresponding to a continuous current, because we have not plotted the case when L = 0. Also, as in Fig. 9, the lines of E.M.F. refer only to the case when T is put equal to unity.

CORRESPONDENCE.

INCANDESCENT LAMP FILAMENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The accompanying table (*see* next page), which illustrates the effect of varying both the size and form of an incandescent lamp filament, may interest your readers.

On reference to column one of this table it will be seen that the comparisons made are under identical conditions of energy, or, more precisely speaking, the kinetic energy expended per unit of cubical content is the same in each case. This being so, it is reasonable to assume that, with equal quality of carbon and under similar conditions of vacuum, all will have the same life.

The term "efficiency" as applied to incandescent lamps can hardly be considered correct, and for the want of a better I have employed the word "economy," which here simply implies the ratio between the energy expended and light emitted.

It is sometimes stated that an efficient lamp will necessarily have a short life, and that the economy in employing such is as long as it is broad. This would be correct if it went a little

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TABLE SHOWING THE EFFECT OF VARYING THE LENGTH AND DIAMETER OF AN INCANDESCENT LAMP FILAMENT.

—	—	—	A	B	C	D	E	F	G	H	I	K	Explanation of reference marks.
	—	—	Length of filament in any convenient unit.	Area of ditto.	Diameter of ditto.	Resistance in ohms when hot.	Current in amperes.	E.M.F. in volts.	Total energy in watts = E × F	Relative cubical contents = A × B.	Degree of energy per unit of cub. cont. representing life of filament = G ÷ H.	Economy or relative extent of rad. surface per watt. $= \frac{C \times A \times 3{\cdot}15}{G}$	
Filaments having circular sections.	1		100	2	1·59	25	2	50	100	200	·5	5	* The diameters given here are those of the circles of which these carbons are sections.
	2		100	1	1·13	50	1	50	50	100	·5	7	
	3		200	1	1·13	100	1	100	100	200	·5	7	
Ditto, having annular sections, solid sec. area = ½ total sec. area.	1		100	2	2·26	25	2	50	100	200	·5	7	† Column C is here "length of sides" instead of diameter, &c."
	2		100	1	1·59	50	1	50	50	100	·5	10	
	3		200	1	1·59	100	1	100	100	200	·5	10	‡ Formula K in this case is altered to $\frac{\left(\frac{C \times 3{\cdot}15}{2} + C\right) A}{G}$
Ditto, having ½ round sections.	1		100	*2	2·26	25	2	50	100	200	·5	‡5·8	
	2		100	1	1·59	50	1	50	50	100	·5	8·2	
	3		200	1	1·59	100	1	100	100	200	·5	8·2	
					length of sides								§ Formula K in this case is altered to $\frac{4 C \times A}{G}$, C to be taken as given in note above (†).
Ditto, having sq. sections.	1		100	†2	1·43	25	2	50	100	200	·5	§5·8	
	2		100	1	1	50	1	50	50	100	·5	8	
	3		200	1	1	100	1	100	100	200	·5	8	¶ Formula K in this case is altered to $\frac{2(M+N) \times A}{G}$ where M and N are the two dimensions given in column C.
Ditto, having rectangular sections whose thickness = ⅛th their width.	1		100	2	4 × ·5	25	2	50	100	200	·5	¶9	

further. As it now stands the impression conveyed is that to work with greater economy as to power, more current must be forced through the filament, with the result of shortening its life, whilst the table, I think, clearly shows that there are other considerations which determine economy of working besides forcing the filament or even improving the quality of the carbon. Filaments marked 2 and 3 throughout have each half the areas of those marked 1, and give, as shown in Column K, an improved economy of about 40 per cent. over that of No. 1, a result that is due to the fact that in the forms given the radiating surfaces are, for equal lengths of filament, proportional to the square roots of their areas, so that reduction of area does not mean a correspondingly large reduction of radiating surface.

It would hardly be safe to assert that the whole interior of the filament is idle as regards emission of light, and probably the high percentages given would require some correction.

The quality of a good carbon should evidently be such as to resist to the highest degree the disintegrating action of the current and its resulting forces, but, assuming we have reached perfection in this direction, the next most important conditions are that it should have sufficient structural strength to withstand ordinary usage or vibration, and as large a radiating surface as possible.

As regards the structural strength of the filament, a recent improvement in this direction has been to support the loop by a separate piece of idle filament projecting from the bottom of the lamp globe. It might also be expected that the annular filament now constructed by some makers would possess greater structural strength, area for area, than the ordinary round or rectangular forms.

Perhaps the most important advantage obtained by diminishing the sectional area of the filament is its improved relation to the external circuit. For example, if it be assumed that the round carbon No. 1 gives 20 candles, then No. 2 would only give 14·2, and to make this equivalent to No. 1 it would be necessary to increase its length by about 41 per cent., which would increase its resistance by the same amount, so that No. 2, although now of the same candle-power as No. 1, would have a considerably higher resistance, and a smaller conductor could be employed whilst still maintaining the same percentage of loss therein.

The table also shows the relative values of different sections of filaments, and on comparing the results it is evident that a riband form of filament, with infinitesimal thickness, having a rectangular form of section, would be best. The illustration given has a thickness half of its breadth, and even with this reasonable proportion between thickness and width, it gives by far the best result. The annular of same solid sectional area comes next; in this the solid sectional area is equal to half that of its total sectional area, and therefore the thickness of its shell is about one-tenth of its mean solid circumference, so that it is considerably thinner than the preceding riband filament.

It will be observed that the riband form of filament has about 80 per cent. more radiating surface than the round, although of equal area. No doubt a riband filament would be more liable to break, and it would be interesting to know if any attempt has been made to construct it in a spiral form for greater structural strength.

It is a common custom with electric light engineers to calculate all formulæ relating to incandescent lamps by aid of a constant, generally given by the manufacturers. This constant expresses the relation between the candle-power given and number of watts required, and in value represents the reciprocal of the figures given in Column K of the table.

The process, though good enough for many purposes, is by no means correct when dealing with lamps of the same electromotive force.

In considering and comparing the relative properties of incandescent lamps it is necessary to determine what functions shall remain constant whilst making such comparisons. It is evidently desirable that the degree of energy to which the filament is subjected should be the same in each case, as well as the quality of the carbon and degree of vacuum; the lamps will then be comparable on a reasonable prospect of equivalent lives. Assuming, then, the above to be the basis for comparison, there will be two distinct methods of constructing lamps of different candle-power, either by altering the length of the filament and keeping the sectional area constant, as illustrated in filaments 2 and 3, which means a constant current and varying E.M.F., or by altering the area and keeping the length constant, which means a constant E.M.F. and varying current. It would be quite possible to construct lamps of different candle-power and same E.M.F. by making variations in both the length and area of the filament, but this could not be done under the same standard of energy.

Now, on referring again to the table, Column K, it will be

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seen that filaments 2 and 3, constructed according to the first of the above methods, have the same factor of economy, so that the figure given by the manufacturers would in this case be a constant for comparing lamps of this class; but a comparison between filaments 1 and 2, which are constructed in accordance with the second method, will show a considerable difference in this respect, which is due, as before stated, to the ratio existing between the area and radiating surface. Now, as the length of the filaments in these lamps will always remain the same, the radiating surface will vary as the square root of the sectional area, and if it be assumed that the radiating surface is proportional to the candle-power, then the candle-power will vary directly as the square root of sectional area; but as the factor of economy given in Column K varies inversely as the square root of the sectional area, it may be stated that the above factor will vary inversely as the candle-power, or that the constant given by the manufacturers will vary directly as the candle-power. For example, take a Swan lamp 20 candle-power, requiring 3·5 watts per candle, then a 10 candle-power lamp of same E.M.F., and working under similar conditions of energy, would take $\frac{10 \times 3{\cdot}5}{20} = 1{\cdot}75$ watt per candle.

This is not to be taken as absolutely correct, but until more accurate data can be given regarding the relation between radiating surface and candle-power under equivalent conditions of energy, it serves to show how erroneous may be the calculations referred to.—Yours, &c.,

N. G. THOMPSON.

4, Queen Victoria street, London, E.C., August 11th, 1886.

INCANDESCENT LAMP PATENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With reference to the reports which have appeared in the daily papers of the proceedings in the Chancery Division of the High Court of Justice, on Friday, the 6th inst., in the matter of the Edison and Swan United Electric Light Company *v.* Holland and the Jablochkoff and General Electricity Company, it is to be feared that the condensed reports referred to of what took place in court may give the public an erroneous impression of the real facts of the case, and in justice to the industry I ask that you will be good enough to afford me space to briefly state the position of the matter.

Notwithstanding that the decision of Mr. Justice Butt against Messrs. Woodhouse and Rawson is now under appeal, the Edison and Swan Company have been threatening the users of lamps not manufactured by themselves with proceedings for infringement, and among others the customers of the Anglo-American Brush Corporation.

My corporation therefore advertised their readiness to indemnify their customers against any proceedings for alleged infringements of patents by the use of the Brush Victoria incandescent lamp, and did, among others, indemnify the Jablochkoff and General Electricity Company, and their customer, Mr. Holland, of the Albert Palace.

My corporation also called upon the Edison and Swan Company, under the provisions of the Patent Act, to justify their threats by commencing proceedings against the Brush Corporation in respect of the lamps in question; but the Edison and Swan Company instituted proceedings against the Jablochkoff Company and Mr. Holland, instead of against the Brush Corporation, who are the manufacturers of the lamps.

Meanwhile the Brush Corporation have been compelled to protect their interests by instituting proceedings against the Edison and Swan Company for infringement of their lamp patents, which cover their manufacture of incandescent lamps, and which action is still pending.

The proceedings in court yesterday were:—Firstly, to confirm an arrangement made out of court between the parties, under which Mr. Holland will remain in undisturbed possession of the lamps already purchased, but will not purchase any more such lamps pending the hearing of the action, or unless Mr. Justice Butt's decision be reversed; and, secondly, to hear an application made by Mr. Holland and the Jablochkoff Company, with the consent of the Anglo-American Brush Corporation, to admit the Brush Corporation as third parties, so that they may defend the action of the Edison and Swan Company *v.* Holland and Jablochkoff. This application was granted by Vice-Chancellor Bacon, with costs against the Edison and Swan Company.

The Anglo-American Brush Corporation are fully determined to contest anew the validity of the patents owned by the Edison and Swan Company, and they have every reason to think that they will do so successfully.—Yours, &c.,

E. GARCKE, Secretary,

Anglo-American Brush Electric Light Corporation (Limited).
112, Belvedere-road, Lambeth, S E.,
7th August, 1886.

AMPERE'S RULE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: If your correspondent thought that I used the words "absolute negative charge" in the sense of a negative charge which has no corresponding positive charge bound to it anywhere, he is quite mistaken. I used the word "absolute" in much the same sense as "actual," and meant thereby that the negative electricity was not merely induced in particular spots, but that the earth, on the whole, had more negative electricity than positive in it or on it.

The potential of any conductor depends both on its own charge and on the charges of neighbouring bodies. If the conductor is infinitely distant from all other charged bodies, its potential will depend on its own charge alone. If it has no charge its potential will be zero. This is true zero potential. We call the potential of the earth zero, but probably it seldom is so, accurately. If the conductor in this case (*i.e.*, when infinitely distant from all charged bodies) has a positive or negative charge, its potential will be of the same sign as its charge.

What I mean by the earth's having an absolute negative charge is that its potential would be negative if it were infinitely distant from all charged bodies; it would attract a particle of positive electricity and repel one of negative (supposing this latter not close enough to cause induction). In the case of a charged body infinitely distant from all other bodies the corresponding charge of opposite sign must still exist according to the ordinary theory of statical electricity, but it will be infinitely distant. When a body is near charged bodies it does not follow that its charge is of the same sign as its potential. The potential of the earth is sometimes positive instead of negative, and possibly its electrification is continually varying.

But generally potential increases as we pass outward from the earth; hence force lines proceed from somewhere to the earth, though it is doubtful where the positive electricity lies whence they proceed. Many seem to hold the opinion that the positive charge lies in the upper regions of the atmosphere, and this is sometimes partially brought down to the earth by the thunder clouds and discharged in the lightning.

In one of Rowland's two experiments the rotating disc had a negative charge. This charge was bound to the positive charges on two gilt glass discs connected with the earth. On Maxwell's theory the electrostatic action between the rotating and stationary discs in Rowland's experiment should cease when the rotating one has reached a certain velocity. I do not know whether other observations than those on the magnet were made at the time, but if not it would have been a curious thing to observe whether there was any flow from the stationary discs as the velocity increased, owing to the diminution of the statical action of the electricity on the rotating one.—Yours, &c.,

J. M. CHAMBERS.

NOTE.—In my last letter I said statical electricity had no effect on a magnet. I should have said "no magnetic effect." A magnet would be affected by statical induction when a charged body was brought up to it, like any other conducting body.

[CORRESPONDENCE *continued on page 281.*]

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

All communications to be addressed to 1, *Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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THE HOUSE OF LORDS' COMMITTEE ON ELECTRIC LIGHTING.

A Blue Book has just been published containing the evidence given before a Select Committee of the House of Lords last May on the three Bills then under consideration for amending the original Electric Lighting Act of 1882. Besides a full report of the evidence this volume includes some useful appendices of statistics furnished by several expert witnesses with regard to the comparative progress of the Electric Light in the principal countries of Europe and in the United States; the manufacture and distribution of gas by local authorities who have taken up that line of business; and the actual cost of supplying Electric Light to such places as the House of Commons and the Museums at Bethnal Green and South Kensington. No report is given of the discussions which took place in Committee, but judging by the brief minutes of the resolutions submitted, and the names which appear on either side on the divisions, the Government, as we conjectured at the time, had secured a preponderance of votes for its own Bill, which, except on one point of detail, was fully endorsed in the teeth not only of the friends of the two rival Bills, but of the evidence in support of them.

It will be remembered that the late Government, the members of which had been the framers of the original Act, were at length convinced by the unmistakable facts of the case that a large extension was needed of the period assigned for electric lighting operations before they became liable to be absorbed by the local authorities; and in the end Lord HOUGHTON proposed to double the time of grace, thereby condemning the obstructive legislation of 1882. But the terms of purchase remained the same—that is to say, any Electric Lighting Company at the end of forty-two years could be compelled to part with its business to the parish or town Board for the price of the old plant. Lord BURY, with more good nature than some people consider prudent, accepted the amendment, extending the period to forty-two years, but introduced in his Bill a clause providing that in case of purchase the terms should be such as are usually stipulated for "a going concern." The other Bill, that of Lord RAYLEIGH, made no provision whatever for compulsory sale, but left the Electric Lighting industry to work on precisely those lines which the Gas and Water Companies have enjoyed, subject only to the conditions which Parliament has in recent years deemed it right to impose upon those great monopolies. The difference between Lord BURY'S and Lord RAYLEIGH'S Bills is, perhaps, not very material. Whether a monopoly may be held in perpetuity or only certainly for forty or fifty years is, comparatively, a small matter, seeing that the State can extinguish any monopoly by legislative enactment whenever it is so minded. The really important question is, on what terms shall this be done? for it makes all the difference to the prospects of a business operation if it is only liable to be purchased as a going concern, or, on the other hand, is pretty sure to be confiscated as an extinct concern.

This was the essential point of divergence between the two Bills promoted in the interests of Electric Lighting and the Government Bill framed in the supposed interests of the public. As we have already stated, the evidence was conclusively against Bill No. 3. Men of authority on matters of business were unanimous in declaring that compulsory sale without regard to the value of the business to be sold would be an effectual hindrance to that business being embarked upon, whatever might be the fixed period of exemption; moreover, that in the interests of the public such a provision was inexpedient, for in view of certain loss on the ultimate sale the proprietors would make the public pay for it while they had the chance. "If," as one witness observed, "it is necessary to provide a return of, say, 12 per cent. per annum on the capital that comprises a sinking fund for the return of the capital within a short period, the light must cost a great deal more than if it were only necessary to provide a return of 8 or 6 per cent. per annum." The same witness emphatically declared his belief with reference to the Government Bill that "nobody would look at it," because the majority of prudent people would not dream of going into an investment where, within a measureable distance of time, the thing is absorbed for the value of the material." Another eminent man of business put the whole case very neatly as follows:—"It seems to me that they (the Electric Lighting Companies) would be between Scylla and Charybdis; that they would either have to charge so high a price that nobody would desert gas for them, or that they would charge so low a price that it would not pay them at the end of the time for their risk, and give them a reasonable profit on their investment."

These and other witnesses who spoke to the same effect were men who had no interest in the business of electric lighting; and where there was a leaning to compulsory purchase it was on purely political grounds, or on grounds which are obviously traceable to political prejudices of modern growth, and for which no better reasons could be assigned than that it is desirable the State should reserve the power of compulsory purchase—a power which, as we have already pointed out, the State will always possess without any antecedent reservation. What is really contemplated is a preliminary bargain for a prospective con-

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fication, which the State would not have the face to suggest either now or forty years hence. Nobody denies that State reasons, or even parochial need, may justify the compulsory transfer of private undertakings into public hands; but hitherto one indispensable condition has been complied with, namely, that owners shall be fairly compensated. Any departure from this rule is made none the less odious by postponing it for two-and-forty years, as Bill No. 3 proposes; either the State will rob the company or the company will rob the public—so true is it that you cannot play tricks with the political conscience without disorganising social morality.

Some highly instructive evidence was tendered the Committee on the subject of corporation trading, Sir FREDERICK BRAMWELL, who was under examination during a whole sitting, speaking strongly against it, and giving excellent reasons for his opinion; and Mr. E. O. SMITH, the town clerk of Birmingham, testifying in the opposite sense, with reasons not so excellent. Mr. SMITH betrayed a strong prejudice against the Electric Light, chiefly, it would appear, because a great many corporations have invested in gas manufacture and are afraid of competition. Pressed to explain why he came to advocate terms of purchase for Electric Lighting undertakings vastly less advantageous than those which Birmingham had agreed to in respect to gas, he had nothing to urge except that *at present* investors had sunk no money in the undertakings which had not yet been started. To this his interrogator rejoined, "That is to say, you would like them to risk their money upon terms that if the undertaking is a failure it shall be at their risk, but if it is a success it shall be at your profit?" To which the witness could only reply that that was "a very broad way of putting it," and that a sinking fund would, he thought, adequately meet the contingency—a device which we have already characterised as injurious to all the parties concerned. We have often suspected that the terms of the Act of 1882 were framed with an eye to Birmingham and its imitators; and the glance we have been able to take at the Leeds and Birmingham Town Clerks' revelations under sharp cross-examination have rather confirmed our suspicions. Fortunately the Amendment Act of the late Government has not yet passed; the information now made public by the issue of this Blue Book can hardly fail to influence advantageously the shape of that measure when it comes on for discussion again.

THE MACKAY-BENNETT CABLES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I see from the reports of the half-yearly meeting of the Anglo-American Telegraph Company, held at the Cannon-street Hotel on Thursday, the 29th ult., it was stated by the chairman, Viscount Monck, that "their rivals the Mackay-Bennett cables were giving exceptional advantages to individuals."

This statement was repeated by Mr. Thomas Smith, a shareholder, who, also addressing the meeting, added that these advantages were obtained by allowing rebates to their clients.

I beg to say that this is not the case, as no rebates or discounts have ever been allowed by the Commercial Cable Company to their clients.

I have written to his lordship and also to Mr. Thomas Smith, requesting them to contradict the above-mentioned statements, as they are entirely without foundation and calculated to injure the Commercial Cable Company.

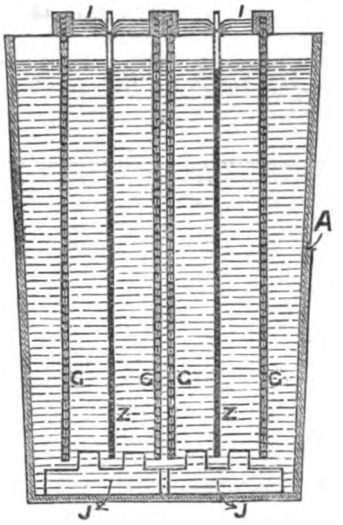
As considerable publicity has been given to the statements above referred to I shall be obliged if you will kindly publish this letter in an early issue of your journal.—Yours, &c.,

CH. A. DILLON, JUN., Managing Director.

96, Gresham House, Old Broad-street,
London, Aug. 10, 1886.

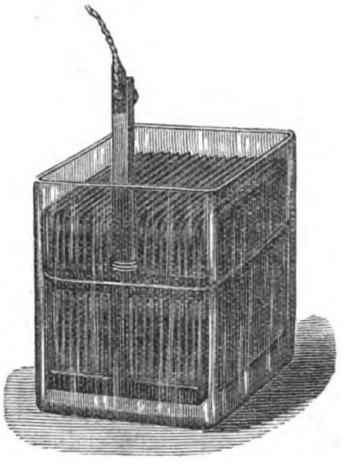
THE LALANDE BATTERY.

We recently had an opportunity of inspecting an installation at 11, Copthall-court, where the electricity necessary for the lamps was generated by means of a Lalande battery. It is well known that very great efforts are being made to obtain a satisfactory primary battery for electric lighting purposes. Not long ago we mentioned the Upward battery, a battery which has received considerable attention lately. The Lalande battery, however, is not of so recent a date, and, according to its proprietors, has passed through the experimental stages, and is now satisfactorily used in practice. The installation in



Vertical Cross Section of Lalande Electric Lighting Cell.
A Iron Cell. Z Z Zinc Plates. G G G G Wire Gauze containing CuO. I I Insulators supporting the lugs of the Zincs, and used as Distance Pieces to separate the Gauzes. J J Insulating Separators between Plates.

the City is by no means an experimental one. It has been, we believe, purchased of the company as a practical means of obtaining the electric light in the offices of Messrs. Borthwick. We believe that the confidence in its action is so great that gas has been entirely abolished so far as those offices are concerned. The battery is placed in one of the cellars of the



Secondary Battery Cell.

building, as shown by our illustration. Upon either side of the cellar 12 iron troughs are placed, six of which form a battery holding some 90 gallons of liquid. Down the centre of the cellar is placed the secondary battery, which is being continually charged by means of the primary, and from which the current is drawn off, so to speak, for use in the lamps as required. So far as the battery itself is concerned, we shall leave the reports of Prof. Tait, Dr. Squire, and others to speak, and devote our attention more immediately to the method adopted by the company in this installation. It will be seen from the report of Dr. Squire that the idea of the company is to obtain a saleable article from the residues of the battery after they

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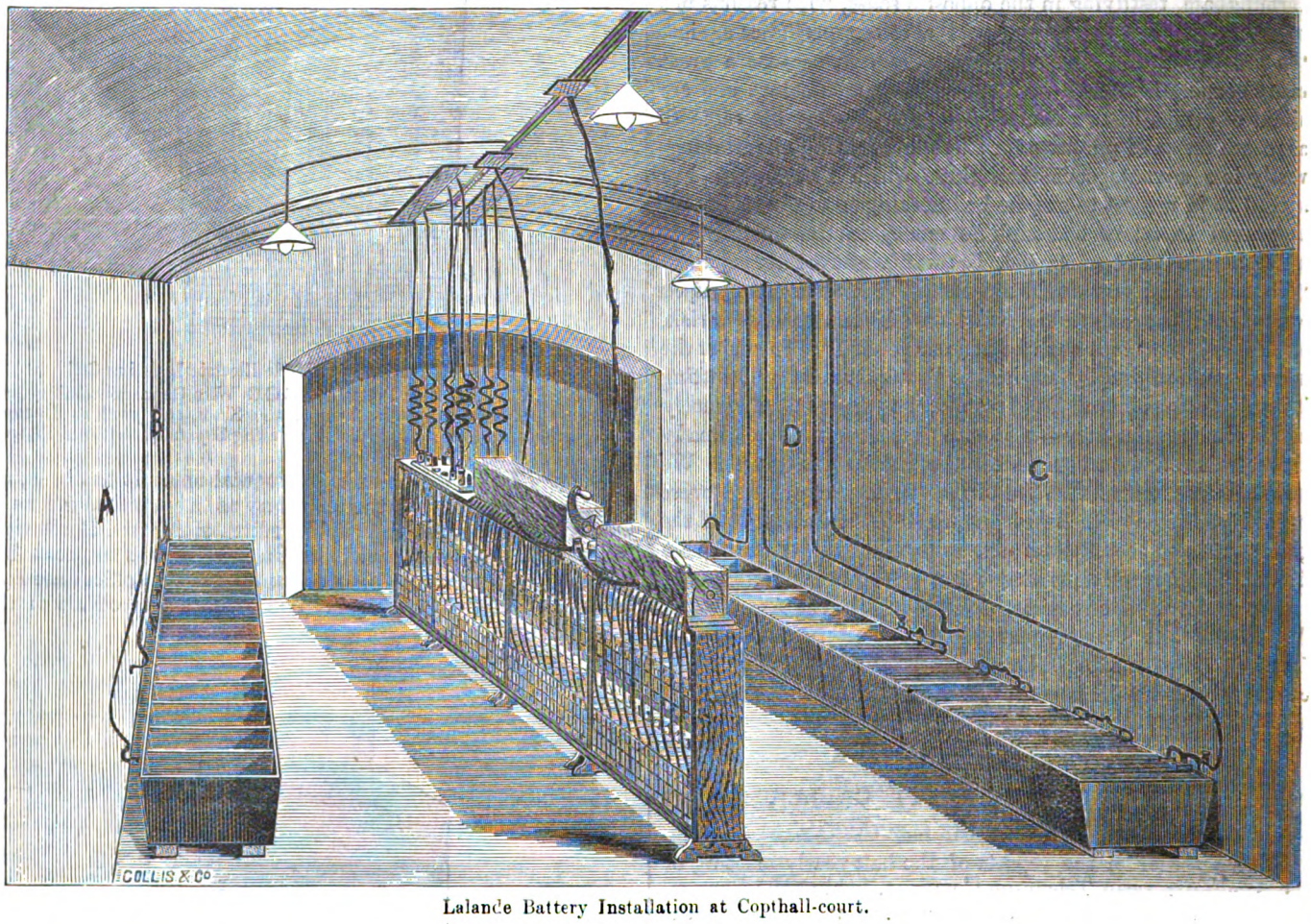
are run down from lighting. In order to do this—as every reader will understand—the work must be performed on a large scale. No one individual user would ever take the trouble to save the residue or to manufacture it into saleable product. The company, however, proposes to collect periodically all the used-up material, to open chemical works, and to obtain what may be termed a saleable by-product, and from this, in reality, to get its profits. If this can be carried out, the users of the electric light upon this system will be placed very much on the footing of the users of gas; in fact, they will be in a better position, in that the use of the electric light is far less dangerous than the use of gas. They will have absolutely nothing to do with the battery, as will be seen; duplicate sets of cells are kept, so that the company can at convenient times and seasons send carts containing the liquid, and by means of a tube, run it from the street into the spare batteries. The residual liquid is placed in large galvanised iron tanks, and periodically carts, supplied with the necessary apparatus of pumps and tubing, pump up this residual liquid and convey it to the factory, where it is treated for the by-products. Of course the whole question comes to be one of pounds, shillings, and pence. Can any company pay a dividend upon its capital under the circumstances here shadowed forth? If they can, the use of this and similar batteries will no doubt gradually extend in many places where the dynamo, steam engine, and gas engine are not applicable. There is absolutely no doubt but that satisfactory installations can be carried out by the means adopted in this instance, so that the only question is one of cost. The following are the reports to which we have referred, and we give them fully, in order that readers may derive their own conclusions.

Principal Jamieson, in his report, among other things, says:—

> The light derived in this manner is absolutely steady, and in every respect equal to that obtainable from accumulators charged by dynamos and driven by steam engines, gas engines, or water power. I find that if the instructions you gave me are attended to, there is no difficulty in putting in and taking out the daily required supply of electricity; in fact, the manipulation of these operations is so simple that they could be performed by any ordinary female servant, as it is only necessary to turn the handle of the commutator to the right or to the left at stated times. For an ordinary house or office requiring ten lamps of 10 candle-power each, for an average of five hours' lighting every day, I find it would be necessary to have *two* separate sets (six cells each) of your Lalande batteries, with from ten to twelve storage cells of sufficient size to accumulate electric energy for two days' lighting. As may be observed from my tests and calculations, the two sets of Lalande batteries would require to be completely refilled about once a fortnight. . . . If it can be satisfactorily proved, upon a commercial scale, that you can produce and find a ready market for the sulphide of zinc white paint (arising from the decomposed zinc plates, with the caustic potash liquid returned to you perfectly pure) without any loss, or at a small profit to cover the expenses of refitting the batteries, then, undoubtedly, you get your electricity for nothing, and you can charge householders whatever amount you find it necessary or advisable in order to suitably remunerate you for simply supplying them with Electric Lighting instead of gas lighting.

The report of Dr. Squire is as follows:—

> At your request I have studied the action of the Lalande battery, and have worked out a process for the recovery and the utilisation of the waste products. Before describing this process in detail, it may be well to explain the construction and action of the battery itself. A primary battery consists of a solution of some substance capable of conducting electricity, into which are plunged two different substances, both conductors, one of which is chemically acted upon by the liquid, while the other is either not at all, or at all events less easily, attacked by the solution employed. When the two substances are united by a conductor exterior to the battery, a current of electricity is set up. The substance most easily attacked (the positive element) is acted upon, while hydrogen gas is liberated on the surface of the other (the negative element). A battery is (other things being equal) more powerful in proportion to the electrical difference in the two substances employed. The more positive the one, and the more negative the other, the more powerful will the battery be. I have just said that, during the action of the battery, hydrogen gas is liberated on the surface of the negative element, but hydrogen is itself powerfully positive, and, as it accumulates on the surface of the negative element, the battery becomes weaker and weaker, until it ultimately comes to a standstill. It is then said to be polarised. In order to obviate this polarisation some means must be employed to get rid of the hydrogen as fast as it accumulates.
>
> With this object in view, it is customary to surround the negative element with some oxidising (depolarising) substance, such as chromic or nitric acids, contained in porous pots, or pieces of black oxide of manganese. These completely effect their object, but they are attended with



Lalande Battery Installation at Copthall-court.

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many inconveniences, such as porous pots, which are soon destroyed, poisonous fumes, &c. The batteries are difficult and inconvenient to charge and discharge, and above all they are expensive, for the depolarising substances are decomposed by the action, and they cannot be regenerated, or, at any rate, the cost of regeneration is so great as to be absolutely prohibitive.

It is the distinguishing feature of the Lalande battery that the depolarising substance can be regenerated with the utmost facility. The battery consists of a plate of zinc immersed in a strong solution of caustic potash opposite the negative element. Unless the circuit is completed, nothing happens; but when this is done, and the battery is in action, the water of the solution is decomposed, the oxygen goes to the zinc, converting it into oxide of zinc, which dissolves in the caustic potash, while the hydrogen is liberated on the negative element. This negative and depolarising element consists of oxide of copper cemented together by means of a cement not acted upon by the solution. As the hydrogen arrives on the negative element, it unites with the oxygen of the oxide of copper, which is thereby reduced to the metallic condition, and the action goes on as long as there is any oxide of copper left. In order to regenerate the negative and depolarising element, nothing is necessary but to withdraw it from the cell, dry it, and heat it to a dull red heat in air. Under these circumstances the oxygen of the air combines with the copper, reproducing the oxide of copper from which we set out. This simple regeneration is most perfect, and I have examined the elements which have been repeatedly regenerated without the slightest deterioration.

The copper being thus disposed of, I turn to the solution of the oxide of zinc in caustic potash, which must either be regenerated for use in the battery, or obtained in the form of a valuable commercial product. Of the compounds of zinc, the sulphide is undoubtedly the most valuable. It is a white body, already largely used as a substitute for white lead, over which it possesses the great advantages of being much less poisonous, and of retaining its colour unchanged under conditions which speedily blacken objects painted with white lead. It is distinguished by great body, or covering power, in which respect it is vastly superior to oxide of zinc, which is also largely used as a pigment. An extremely simple way of regenerating the potash would be to add to the solution of oxide of zinc in potash (spent liquor) a concentrated solution of pure sulphide of potassium. Under these circumstances the whole of the zinc is precipitated as a mixture of sulphide and oxide, while not only is the original potash regenerated, but the potash produced by the decomposition of the added sulphide of potassium is obtained in the free form as well.

Simple and easy as this process looks at first sight, there are serious objections to it.

Firstly, commercial sulphide of potassium is far too impure for the purpose, and the cost of preparing a pure sulphide is prohibitory. Secondly, the mixture of sulphide and oxide of zinc produced in this way is not suitable for use as a pigment. The process which I have devised, and now recommend as yielding excellent results, is the following:—I take any convenient quantity (say 100 gallons) of spent liquor. Into this I pass a stream of sulphuretted hydrogen gas, until the whole of the zinc is precipitated (in the form of impure sulphide), and the potash is regenerated. The precipitate is separated and dissolved in sulphuric or hydrochloric acid. This process of solution is accompanied by the evolution of the whole of the sulphuretted hydrogen used to precipitate the zinc. The gas thus evolved is passed through a second 100 gallons of spent liquor, whereby a second quantity of zinc is precipitated and a second quantity of potash regenerated. The precipitate is dissolved in acid as before, and the gas led into a third quantity of spent liquor regenerating the potash and precipitating, and so on, the same quantity of sulphuretted hydrogen serving indefinitely for the operation of regeneration. The potash being regenerated, it remains to deal with zinc which is now in solution in the condition of chloride or sulphate. The solution is brought to a state of neutrality, and a small quantity of bleaching powder is added to precipitate any traces of iron which may be present. Lastly, the clear solution is precipitated by sulphide of barium, a substance which can be obtained commercially in a state of great purity, at a low price. If the zinc is present in a state of chloride, a perfectly pure suphide of zinc is precipitated, while chloride of barium remains in solution, and can be recovered as a by-product. If the zinc is present in the state of sulphate, not only is the sulphide of zinc thrown down, but the whole of the sulphuric acid, and of the barium present, accompanies it, precipitated in the form of sulphate of baryta This mixture of sulphide of zinc and sulphate of baryta is the ordinary commercial article known as "sulphide of zinc white." The more expensive pure sulphide of zinc is used only when great body is required. The ordinary process for the manufacture of sulphide of zinc consists in dissolving metallic zinc in hydrochloric or sulphuric acids, and precipitating the solution with sulphide of barium. Beyond the metallic zinc, the only raw materials used are hydrochloric or sulphuric acids and sulphide of barium. These are the only materials used in the regenerative process, and in precisely the same quantities, neither less nor more. It follows, then, that starting from the metallic zinc, the sulphide of zinc white can be obtained as cheaply in the one case as in the other. But, in the regenerative process, the zinc, before it becomes sulphide, has given out all the electricity it is capable of developing, the other elements of the battery being regenerated for use again. In other words, a company working the Lalande battery with the regenerative process would obtain, on the "sulphide of zinc white," the same profit as the other manufacturers of the article, while they would get their electricity for nothing.

I estimate that the expenses of manufacture of the "sulphide of zinc white" would not exceed (and will probably be less than) £4 per ton. The "sulphide of zinc white" is, I understand, quoted in the market now at 20s. per cwt. I propose to take it at 15s. per cwt. On this basis, and making proper allowances for loss, the profit on the sulphide of zinc white obtained from each charge of the battery would appear to be:—

Cr.				
230lb. caustic potash	at 22s. cwt.	£2	5	2
60lb. scrap zinc	at 14s. ,,	0	7	6
700lb. sulphide zinc white	at 15s. ,,	4	13	3
		£7	5	11
Dr.				
180lb. zinc plates	at 20s.	£1	12	1
240lb. caustic potash	at 22s.	2	7	2
Wear of connections, say		0	4	0
360lb. sulphide barium	at 7s.	1	2	6
285lb. chamber sulphuric acid	at 2s.	0	5	1
Labour, &c.	at 4s.	1	6	0
		£5	16	10
Showing a profit on each charge of...		£0	9	1

while the electricity is obtained for nothing. I am not aware what is the quantity of sulphide of zinc white manufactured at the present time, but I believe it to be considerable, and I understand that its use is rapidly extending, as its advantages become known. There is also, I understand, a considerable demand for sulphate and chloride of zinc, especially the latter. Both these salts are obtained in the course of the process, and it is obvious that they may be sold in this state, to supply any demand that may exist, instead of converting them into sulphide.

In a postscript to his report Mr. Squire adds:—"Since writing the above, I have made inquiries as to the probable amount of sulphide of zinc white which could be disposed of. One paint manufacturer informed me that, from experiments he had made, the covering power of sulphide of zinc is greater than that of white lead, and that he had one customer who would take about 750 tons per annum. A foreign importer of colouring matters told me that he had imported sulphide zinc white, which he sold in parcels of sixty or seventy tons. He had no doubt he could dispose of very considerable quantities. Generally, it appears that the trade in this article has, up to the present time, been very insufficiently pushed. There appears, also, to be a considerable demand for india rubber manufacturers."

Mr. Stanley C. Currie thus writes:—

In my explanatory pamphlet for a system of electric lighting by means of the Lalande battery, in conjunction with the accumulators, I have stated (page 16) that a set of six cells, the same size as those supplied to Profs. Jamieson and Tait for the purpose of being tested, gives on an average 6,000 ampere hours (useful), and that the proportional consumption of zinc for this amount is 120lbs. Now, in calculating the useful energy to be obtained, we must of course multiply the ampere hours by the average electromotive force at which the battery works during its run. On page 6 in my pamphlet, I have stated that E.M.F., through high resistance, is slightly under 1 volt. Prof. Tait gives it as ranging between ·83 to ·94 volt. Now, the working E.M.F. varies according to rate of discharge, and the state of exhaustion of liquid. For useful work, where the primary battery is not being used in conjunction with accumulators, the limit of fall, according to my experiments, should be not less than ·6 volt. That is to say, one can get 6,000 ampere hours out of above cells at a useful rate of discharge, say 35 amperes, without the E.M.F. falling below ·6 volt. Taking these figures, a set of six cells should give $6{,}000 \times 6 \times 6 = 21{,}600$ watt hours. The rate of discharge, as I stated (page 8) in my pamphlet, depends upon various causes, but any particular sized cell can be arranged to give a larger or smaller discharge rate according to surface of plates.

Prof. Tait does not mention the average rate at which his battery was discharged, but I presume it was less than 40 amperes, for he states that the E.M.F. never fell as low as ·6 volt, and was on an average ·7 volt. The useful energy, according to Prof. Tait, is thus

$$6{,}000 \times \cdot 7 \times 6 = 25{,}200 \text{ watt hours.}$$

Whereas, I never allow in practical work for more than 21,600 watt hours, Professor Tait only obtained 5,556 ampere hours out of his battery, still

$$5{,}556 \times 6 \times \cdot 7 = 23{,}335 \text{ watt hours,}$$

which is 8 per cent. above what I allow.

The consumption of zinc, however, in Professor Tait's battery was 123lb., whereas I put it at 120lb., which thus brings the total result of his experiments to—1lb. of zinc gives 189·71 watt hours, or putting one electrical horse-power hours = 746 watt hours.

3·93lb. of zinc = one electrical horse-power hour.

Now, Professor Jamieson, in his report upon these batteries, *which were charging accumulators*, gives

4·28lb. of zinc as yielding one horse-power hour.

Taking my figures, viz., ·6 volt per cell of 6 cells, giving 6,000 ampere hours and consuming 120lb. of zinc—

4·19lb. of zinc = one horse-power hour.

Thus Prof. Tait, notwithstanding the fact of his battery consuming 3lb. more zinc than it should have done, and getting 5,556 ampere hours instead of 6,000, gave on the whole better results than Prof. Jamieson's, and also better than I allow for. Thus my figures represent a very fair mean between the two independent results. Prof. Tait found there was local action in his battery. This is sometimes the case, especially when the battery is first charged, from impurities in the zinc. It is for this reason I only allow for 6,000 ampere hours per 20lb. of zinc in each cell, or 300 ampere hours per pound of zinc consumed, whereas, in many cases, it is considerably above 300 ampere hours. In some instances I have known it as high as 350 ampere hours per pound, which is very little less than

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the theoretical amount. The zinc which has hitherto been used is the ordinary commercial article, and I may mention the fact that arrangements are now being made by the Standard Company for obtaining zinc specially rolled for the use of these batteries, by which means a purer article will be used. The potash also frequently contains impurities, which will not be the case after the first treating by Dr. Squire's process. Thus, when in regular work, each battery may be relied upon to give over 6,000 ampere hours per 120lbs. of zinc, which in the case of charging accumulators, is equivalent to 12,000 watt hours (useful) per 120lbs. of zinc consumed, or 100 watt hours per lb. of zinc, or 7·46lbs. of zinc per horse-power hour. Prof. Jamieson obtained from the three batteries he tested an average of 10,725 watt hours, and in one 14,474 watt hours, the consumption of zinc being in proportion.

It will thus be seen that taking the two reports upon four different batteries, Profs. Jamieson and Tait's experiments fully corroborate the figures I have given as representing the fair average work of the battery, and the weights and quantities upon which Dr. Squire's estimate is based.

Prof. P. G. Tait has written the following report upon the examination of the battery by Mr. Peddie:—

I enclose the report of the examination which Mr. Peddie has made for you of the electrical qualities of the Lalande battery. He is a careful and accurate experimenter, and has used instruments of precision, so that his results may be fully relied on. He describes the precautions taken to obtain a set of cells fairly representing an average, and he confirms the statements which have been already made to the effect that

1. The average electromotive force of a cell is always above 0·6 volt.
2. Each cell, when freshly charged, is capable of furnishing in all as much electricity as would correspond to that which passes when a current of one ampere is maintained for about 6,000 hours, *i.e.*, in the new-fangled nomenclature somewhat over 20,000,000 (twenty million) coulombs.

I hope that this independent confirmation of the statements made will be satisfactory to you.

Report on the Lalande Battery by MR. W. PEDDIE.

The battery to which this report refers consisted of six cells, selected at random from a large number prepared by Mr. Boothby. The zinc plates and the liquid were supplied by the company without selection. The report deals with two points only; first, the *electromotive force of the battery;* and second, the *total quantity of electricity* obtained from it. The company guaranteed the E.M.F. of each cell to be not less than 0·6 volt when the battery was in efficient working order. They stated also that the six cells should supply, before they ceased working, a quantity of electricity not less than that given by a current of intensity one ampere continued for 6,000 hours. The battery might cease working properly for various reasons. For example, the E.M.F. might fall too low, or the current might become very feeble for other reasons. But, in any case, I was requested to stop the battery whenever the specific gravity of the cell liquid became so high as to give a reading of 90 divisions on a Twaddle hydrometer, which the company furnished. It must be distinctly understood, then, that this report deals *only* with the questions of *E.M.F.* and *whole quantity of electricity* furnished. No account is taken of intensity of current through a given resistance, or of the efficiency of the battery, or of any other questions beside the two specified, except in so far as they have a bearing on these two. As regards intensity, for example, the condition required by the company was not satisfied as tested by their own instruments when the battery was used to charge ten of their accumulators. This may or may not have been due to imperfection in the accumulators, not in the battery.

Local Action.—The average weight of each zinc plate was 23lb. 7oz. when the battery was first set up. To test the cells for local action, which seemed to be considerable, they were left on open circuit for a fortnight. In that time the average loss of weight of each plate was 2lb. This action continued during the whole time of testing the battery.

E.M.F.—The instrument used to measure the E.M.F. of the cells was a Thomson quadrant electrometer. It was sufficiently sensitive to indicate a difference of potential equal to 0·01 volt. The E.M.F. of each cell was tested against a standard Latimer Clark cell, and also against a standard Daniell. The correctness of the standards was further tested by means of absolute measurements with a Helmholtz tangent galvanometer. There could be no error greater than 1 per cent. At starting the E.M.F. of the cells ranged from 0·83 to 0·94 volt. It fell slowly as the cells were more and more worked out; but in no case did it fall to the value 0·6 volt.

Quantity of Electricity.—The battery was at first used to charge ten accumulators in multiple arc. This was done for about 20 hours in all. Afterwards, the battery was simply run down through a metallic resistance. The current was in all cases measured by a Helmholtz tangent galvanometer. In this instrument any error due to variation in the horizontal intensity of the earth's magnetic force could be neglected in comparison with possible error in reading the scale. This error might be the 10th part of a degree. As the deflection was about 40 degrees, this involved only an error of 1 in 250 in the estimation of the current strength. The time for which the current was allowed to run at a stretch, varied from rather less than two hours to slightly over 47. The deflection varied from over 40 degrees to about 32 degrees as the battery was getting worked out. There was only a single exception to this statement when the deflection averaged only 25 degrees. This, however, was due to heating of one of the battery connections. The cells stopped working while the liquid was such specific gravity as to give a reading of 83 divisions on the hydrometer. At this stage, the deflection of the galvanometer fell to one-fourth of its value at starting, within a quarter of an hour, and diminished still farther until it indicated a current of only one-tenth its original amount. This recurred every time the experiment was repeated, although all the battery connections were taken down and polished to make certain of good contact. Some of the zinc plates were nearly worn through, so that the increase of resistance due to this probably caused the stoppage. The total quantity of electricity obtained was equal to that given by a current of intensity one ampère, continued for 5,556 hours. The possible error in this number cannot be more than ±20. The weight of zinc left was 158lb. So the above quantity of electricity was obtained from the consumption of 123lb. of zinc. The average E.M.F. of each cell would be about 0·7 volt. Hence a rough estimate of the energy in the circuit can be got.

Conclusions.—As regards E.M.F., the battery tested has satisfied the condition that the E.M.F. of each cell shall not be under 0·6 volt. As regards quantity of electricity, the required amount was very nearly, but not quite obtained. But it is probable that had the battery been used during the first fortnight, instead of being left on open circuit for the purpose of testing local action, the required amount would have been exceeded.

THE "KROTOPHONE"—A NEW FORM OF TELEPHONE.

Many variations have already been devised upon the telephone receiver in every-day use, and few possess such decided novelty as to attract more than a passing notice; but a form of receiver which has recently been devised merits some attention, as the inventor does away with the use of all magnets, diaphragms, helices, secondary currents or induction coils. The principle upon which Mr. Edward S. Spaulding, of this city, the inventor of this novel instrument, bases its operation, consists in reproducing the human voice through the medium of crepitations or minute crackling sounds or detonations. He accomplishes this by causing the original disturbances in the transmitter to be sent over the line so as to affect the receiver and cause it to give forth a series of crepitations or intermitting detonating sounds.

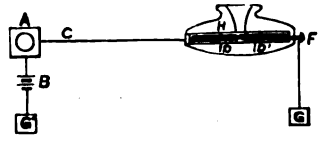

FIG. 1.—The Krotophone.

The illustration, Fig. 1, shows the original form of instrument employed, and Fig. 2 the modified and improved apparatus. As in the ordinary system, any form of microphone transmitter shown at A may be employed. Within the case H, Fig. 1, there are two carbon points D D', which form part of the circuit C, one of the points D being rigidly secured in the receiver H, and the other

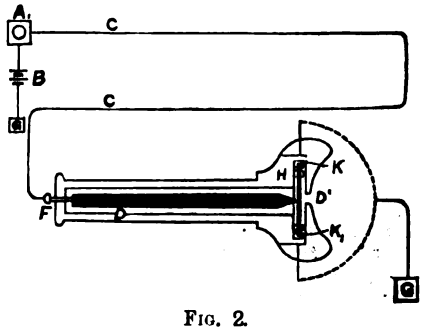

FIG. 2.

point D' being adjustable with reference to the other point by means of the screw F.

This constitutes the entire receiver. The theory upon which the instrument operates is so novel that we prefer to give it in Mr. Spaulding's own language, as set forth in the patent recently granted to him.

"For the sake of illustration we will assume that the circuit consists of a battery, line, and the receiver shown in Fig. 1 be used as a transmitter, and a similar instrument be used as a receiver proper. Assuming that the current passes through the carbon pencils in parallel lines, any disturbance of the point of contact of these pencils in the transmitter will produce a series of crepitations, which cause a series of corresponding electrical impulses to be transmitted over the circuit. Referring to the receiver, this circuit, passing in parallel lines through the pencil D, causes its points of contact with the opposite pencil D' to vary by reason of the elongation and contraction of the pencil D, due, for want of a better term, to the polarisation of the molecules or atoms of the pencil. Now, assuming that through the pencil the current passes in a series of many parallel lines, then the movement of the atoms

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in each of these lines would be uniformly similar and in parallel lines, and thus a disturbance created in the receiver corresponding to the impulses affecting it, which impulses in turn correspond with and depend on the primal disturbances in the transmitter. Now, then, it being shown that the polarisation or disturbance of the atoms in the pencil D in the receiver is produced, I have noted that this result is accompanied by a series of crepitations or crackling sounds, which are clearly distinguishable from even the faintest sounds when produced by vibrations or other cause, and from this distinction I infer that the said crepitations are strictly 'neutral,' and so denominate them. Therefore, as such crepitations are individually neutral when they are arranged in constantly-varying groups, corresponding exactly to the primal disturbances which cause them, and thus if articulate sounds be the primal cause of the disturbance in the transmitter, articulate sounds will be the effect in the receiver."

Mr. Spaulding has found that when two pencils of carbon are used as the receiver the sounds will be audible and distinct, but faint; and to overcome this objection, he replaces one of the pencils by a plate of carbon of such size and quality as to be non-sonorous and non-vibrating, as shown in Fig. 2. This plate is provided with a circumferential ring K, and the plate D′ has a suitable elastic packing-ring to prevent fracture when rigidly secured in place in the holder H. In this form of receiver the current passing as before in parallel lines through the pencil D, and thence to the plate D′ from the point of contact of the pencil, the current then rapidly diverges in every direction toward the metallic ring, and thence to the ground, as before. This construction gives an amplied sound, and this effect Mr. Spaulding attributes to the radial or diverging paths the current takes. In the first form of receiver described the current passes in parallel lines, and the movement of the atoms on each of these lines is uniform, and consequently the crepitations are faint; but in the second instance these several lines are not parallel but divergent, and increased crepitating effect is produced.

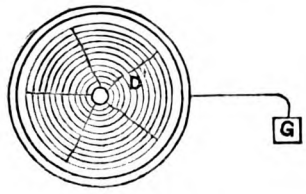

Fig. 3.

The illustration Fig. 3 shows the circumferential connection of one of the carbon points.—*Electrical World.*

THE "CHALLENGE" MOTOR.

At a recent meeting of the Electrical Section of the American Institute, Mr. John M. Pendleton exhibited to the society a small electric motor of his own design which embodies several novel features. Mr. Pendleton remarked that the general introduction of

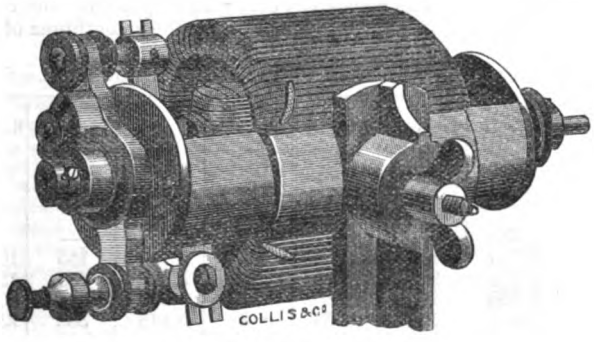

Fig. 1.—Challenge Motor.

electricity had drawn considerable attention to electric motors lately from the recognised fact that power is not only more readily transmitted by electricity, but also on account of the facility with which it may be subdivided and distributed without loss—a point in which neither steam nor gas engines can compete with it.

The motor, which is shown in perspective in Fig. 1, weighs forty ounces, and is capable of developing power sufficient to run a sewing machine or other light running apparatus, such as a dental drill, mallet, or a fan.

The armature of the motor, which is shown detached in Fig. 2, is of the three-pole type, and each of the three segments of the commutator is consecutively cut out in such a manner as to reverse the polarity of the pole of the armature so that for one-half the distance of the pole piece attraction takes place, and during the other half repulsion.

This construction obviates any dead point, and the motor starts instantly at any position of the commutator. This is evidently an indispensable quality in a motor designed to operate intermittently, stopping and starting at frequent intervals. Such work also frequently requires a change in speed, so as to run fast or slow, and this has also been provided for, by making the brush holder adjustable. The latter is controlled by a spring which normally maintains it at the position of maximum speed. By rotating the brush

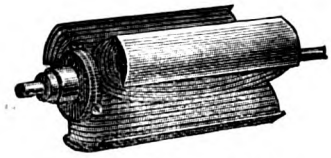

Fig. 2.—Armature of Motor.

holder, however, the position of contact, and hence the speed, can be varied at will from the maximum down. This shifting of the brushes doos not require any manipulation by hand, but is accomplished by a cord attached to a treadle, thus leaving the operator's hands free to guide the work.

THE HEATING OF AERIAL CONDUCTORS BY ELECTRIC CURRENTS.*

BY J. GILBERT WHITE, PH.D.

Introduction.

While engaged on some tests for the Franklin Institute at the Electrical Exhibition, in the fall of 1884, the writer found it necessary to consider the effect of heating and consequent change of resistance of aerial conductors carrying electric currents, and was unable to find any data by which the change of temperature due to the passage of a given current under different conditions of exposure could be determined. It had been noted that, in some cases, covered wires were less heated than naked by the same current, and Sir W. Thomson had shown by mathematical analysis that such should be the case for certain values of emissive and conducting powers. But to what extent these conditions obtained in practice, whether covered wires in general kept cooler than naked, or did so only in exceptional cases, had not been determined, and nothing, so far as the writer knew, was known of the relation that existed between the heating of covered and naked wires for any particular case.

It seemed, therefore, desirable that such experiments should be instituted, and in the winter of 1884-5, the writer proposed to Mr. J. G. White, then pursuing a course of graduate study at the Cornell University, to make a thorough study of the subject both theoretically and experimentally. The method adopted for the experimental investigation made it necessary to have continuous wires partly covered and partly naked. These were obtained through the courtesy of the Electrical Supply Company, of New York, who induced manufacturers to prepare for the purpose samples of wire in lengths of about 100ft., half covered and half uncovered, of a great variety of styles of covering. The investigation proved a much more extended one than was anticipated, and Mr. White having accepted a position in the University of Nebraska, was obliged to leave it before completing all that had been planned. It is believed, however, that the results so far obtained are of sufficient value to warrant their publication, and it is expected that the investigation will be continued. WM. A. ANTHONY.

Physical Laboratory, Cornell University,
Ithaca, N.Y., May 10, 1886.

The heating of conductors by electric currents is a subject of great practical as well as theoretical interest. It constitutes a leading factor in many of the electrical engineering problems of the day, especially in those of electric lighting and transmission of power. All electricians are familiar with the heating of wires by currents, and know that overheating is not economical, injures the insulation, and may even lead to firing of buildings or ordinary combustibles.

Yet very little has been written in this country on the subject; and, so far as we can learn, no experiments have been made.

* From the *Electrician and Electrical Engineer* (New York).

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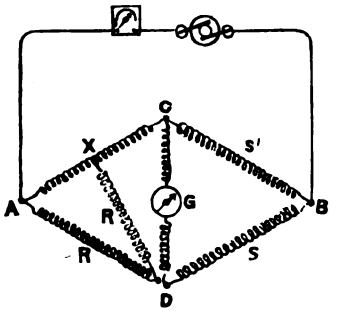
Letters from several of the leading electricians of the country show that quite diverse opinions are held on the most important and practical problems connected with the subject. Furthermore, many of the practical electrical engineers compute the size of wire to be used for any purpose by the rule (prescribed by the Board of Underwriters) of allowing a certain number of amperes current per square inch cross section of the conductor. This rule, as we shall show later, is proven to be wrong by theory and by experiment, and might lead to serious consequences if the computations were for large currents.

In Europe a number of articles have appeared in the scientific periodicals which have discussed the various questions connected with electric conductors ; but the results arrived at have been quite unlike, and very few have gone into any experimental verification of their theoretical deductions. It has therefore seemed wise to undertake some experiments which might verify the results of the theoretical solutions which might be found in other articles or which might be deduced. A description of the method of conducting the experiments and a synopsis of the results will now be given in order that these results may be referred to from the theoretical discussions given later in this paper, and the results reached by the two methods compared.

The currents used in the experiments were obtained from a Gramme generator, independently excited by a small Weston generator. By having a proper set of resistance coils in the "field" of the Weston machine and also between the Weston and the "field" of the Gramme machine, the amount of the current could be varied at will. The temperature of the wire experimented upon was determined by its resistance, which was measured by means of a Wheatstone bridge.

An idea of the connections may be obtained from an inspection of the following figure :—x consists of the wire under consideration. When two wires were to be compared they were joined and the current sent through them in series. By means of a temporarily devised mercury key the connections could be made so as to give R the position shown full or dotted. By determining R and R′ alternately, we get the values for the resistance of one wire and of both. By subtracting the average



value of R′ from the average value of R, the value of the resistance of the other wire could be obtained. R and R′ were readings on one of Elliott Brothers' four dial resistance boxes ; and since they were always thousands of ohms, any slight difference in the resistance of the connecting wires in the two positions would be entirely inappreciable. s was a length of No. 00 insulated wire very loosely coiled so as to be well ventilated. x was in most of the experiments a No. 16, No. 18, or No. 20 wire, and hence s, being so much larger than x in diameter, would not be appreciably heated by the currents which were used to heat x.

At all events, all the experiments of practical significance consisted in the comparisons of two wires ; and, since any slight alteration of s would make the same percentage of difference in R and R′, such a change would not vitiate the results. A little study of the experiments in the results of which this slight change in s would introduce *any* error, shows that, at most, this error would be only a fraction of one per cent. Owing to the variable factors which enter into these results, this is considered as within the limits of attainable accuracy for these particular experiments. s was a part of the resistance of an ordinary resistance box, and remained constant during any set of experiments ; but was varied when a new wire was placed at x so as to have R as large as possible in all instances. Connections were so made that by keys on the resistance box containing R the circuit A R D S B could be closed, and, immediately afterwards, the galvanometer circuit. As x and s were only fractions of an ohm, and as (R+S) was always thousands of ohms, the current which flowed through R and S for the short time during which the circuit A R D S B was closed was very small ; and R and S were not appreciably heated. G was a delicate galvanometer.

The above description shows that the bridge was so arranged that the results obtained from its readings can be relied on. In each of the experiments the resistance of the wire x was obtained, when the wire was cold, by means of one or two gravity cells. Then as only x and R changed during the experiment, the increase in R would enable the per cent. of increase in x to be computed. The temperature of x was then computed, on the assumption that the resistance of x increased 0·388 per cent. for each rise of one degree centigrade. This assumption is not exact; since $R' = R(1 + at + bt^2)$, in which equation R′ is the resistance at any temperature t, R the resistance at zero, and a and b are constants determined experimentally. Now b is so small in comparison with a, that it is only when t becomes of considerable magnitude, that the second term becomes worthy of attention. The calculations have therefore been made as indicated above.

To determine the current flowing at any time one of Thompson's ammeters with sliding magnet and needle was connected in the main circuit. The constant of this instrument was determined by means of the copper voltameter, and found to be 5·2608, or with instrument set

at 32	current	=	·1644 × deflection
,, 16	,,	=	·3288 × ,,
,, 8	,,	=	·6576 × ,,
,, 4	,,	=	1·3152 × ,,

Other determinations by other persons, during the progress of the experiments given below, gave almost exactly the same result. The experiments are given below not in the order in which they were made ; but in what seems to be the logical sequence.

Experiments, Set 1.

To determine the law of variation of the temperature of a conductor after starting through it a current of constant intensity. To determine this law the main circuit was so arranged that it could be closed by means of a mercury key at any instant. Several of the students in the laboratory kindly assisted in this experiment ; so that the following arrangement could be made. One person observed and took frequent readings on the ammeter, to see that the current remained steady. Another closed the circuit at the beginning of a minute ; at the expiration of each half minute thereafter he called out a signal, having given a warning signal five seconds before.

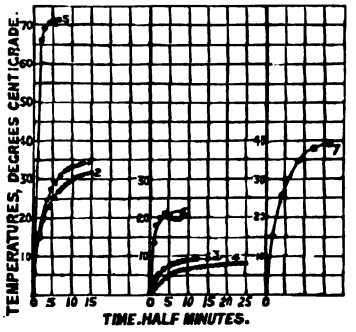


Plate I.

The writer was stationed at the "bridge," and maintained, by changing R, as nearly as possible a balance, calling out the reading of R to another person at the end of each half minute. Of course the exact values of R at the precise instant could not be determined, owing to its constantly changing magnitude ; but fairly accurate results were obtained as is shown by the smoothness of the curves on the cross section paper. In laying out these curves, the rise in temperature of x in degrees calculated as explained above,

TABLE I.—Experiment 1.—Set 1.

Time in half minutes.	Values of R.	Increase in values of R.	Rise in temp. of x.
0	3,735	—	—
1	3,880	145	9·66
2	3,960	225	15·00
3	4,030	295	19·66
4	4,070	335	22·33
5	4,107	372	24·80
6	4,135	400	26·26
7	4,160	425	28·33
8	4,173	438	29·20
9	4,182	447	29·86
10	4,190	455	30·33
11	4,196	461	30·73
12	4,200	465	31·00
13	4,202	467	31·13
14	4,203	468	31·20

TABLE II.—Experiment 2.—Set 1.

Time in half minutes.	Values of R.	Increase in values of R.	Rise in temp. of x.
0	3,757	—	—
1	3,910	153	10·20
2	3,990	233	15·41
3	4,060	303	20·20
4	4,115	358	23·86
5	4,155	398	26·13
6	4,180	433	28·86
7	4,205	458	30·06
8	4,223	476	31·26
9	4,240	493	32·86
10	4,250	503	33·53
11	4,255	508	33·86
12	4,258	511	34·06
13	4,258	511	34·06
14	4,255	508	33·86

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was taken as an ordinate, the number of half minutes since the closing of the circuit being taken as the corresponding abscissæ. The results of the experiments are tabulated below, and the curves plotted on cross section paper (Plate I). Experiments 1, 2, 3, 4 were made with Clark insulated wire; 5 and 6 with bare wire of same size, 0·038in. in diameter.

TABLE III.—Experiment 3.—Set 1

Time in half minutes.	Values of R.	Increase in values of R.	Rise in temp of x.
0	3,746	—	0·0
1	3,785	39	2·60
2	3,810	64	4·26
3	3,827	81	5·40
4	3,842	96	6·40
5	3,854	108	7·20
6	3,862	118	7 86
7	3,868	124	8 20
8	3,872	128	8·46
9	3,878	134	8·93
10	3 880	136	9·06
11	3,882	138	9·20
12	3,883	139	9·26

TABLE IV.—Experiment 4.—Set 1.

Time in half minutes.	Values of R.	Increase in values of R.	Rise in temp. of x.
0	3,735	—	—
1	3,762	27	1·80
2	3,782	47	3 13
3	3,795	60	4·00
4	3 806	71	4·70
5	3,815	80	5·33
6	3,821	86	5·73
7	3,826	91	6·07
8	3,832	97	6·44
9	3,836	101	6·70
10	3,839	104	6·93
11	3,841	106	7·07
12	3,843	108	7 20
13	3,844	109	7·27
14	3,845	110	7·33
15	3 847	112	7·48
16	3,848	113	7·54
17	3,849	114	7·60
18	3,851	116	7 73
19	3,852	117	7 80
20	3,853	118	7·86
21	3,854	119	7·93
22	3,855	120	8 00
23	3,854	119	7 93
24	3,853	118	7·86
25	3,854	119	7 93

TABLE V.—Experiment 5.—Set 1.

Time in half minutes.	Values of R.	Increase in values of R.	Rise in temp. of x.
0	3,377	—	—
1	—	—	—
2	4,370	993	66 20
3	4,420	1,043	69·53
4	4,440	1,063	70·87
5	4,465	1,068	71·20
6	4,465	1,068	71·20

TABLE VI.—Experiment 6.—Set 1.

Time in half minutes.	Values of R.	Increase in values of R.	Rise in temp. of x.
0	3,377	—	—
1	3,580	203	13·53
2	3,650	273	18·20
3	3,675	298	19·86
4	3,678	301	20 67
5	3,671	294	19·73
6	3,674	297	19·80
7	3,674	297	19·80

(To be continued.)

LEGAL INTELLIGENCE.

Field v. Bennett.

On Monday, in the Court of Queen's Bench, before the Lord Chief Justice and Mr. Justice Denman, Sir Charles Russell, Q.C. (with whom was Mr. Danckwerts), moved on behalf of the defendant in this case to set aside the judgment given in it for the plaintiff for £5,000, and all subsequent proceedings, on several grounds. The plaintiff, Mr. Cyrus Field, is an American, and well known from his connection with the telegraph companies of the United States, and the defendant is Mr. James Gordon Bennett, the proprietor of the *New York Herald*, which paper has an office in London. His general representative in this country is Mr. Oakey Hall. The action was one brought to recover damages for libel in which the plaintiff was charged with being an unfit person to be the director of a commercial undertaking. On February 26, 1885, the writ was served upon Mr. Hall. On April 1, 1885, the Court of Appeal, consisting of Lord Justice Baggallay and Lord Justice Lindley, made an order for substituted service on Mr. Bennett by service of the writ personally on the defendant, Oakey Hall, the plaintiff undertaking to accept short notice of motion to set the writ aside, and the defendant being entitled to serve such notice without submitting to the jurisdiction. By the order the plaintiff was also to undertake not to sign judgment against the defendant Bennett without leave of the Court at the trial or otherwise. A previous application for an order for substituted service had in fact been unsuccessfully made to the Divisional Court (1 *The Times* "Law Reports," 374). The substituted service had been effected on Hall on April 2, 1885, and on April 28 the statement of claim had been delivered as against Hall, and filed as against Bennett in accordance with Order XIX. On July 12, 1886, the learned counsel for the plaintiff had applied *ex parte* to the Divisional Court and had obtained leave to sign interlocutory judgment against Bennett. On July 26 the damages had been assessed before Mr. Under-Sheriff Burchell at £5,000. The present application was one made on the part of Mr. Bennett to set aside the judgment and the substituted service on three grounds—(1) that the case was not one in which substituted service could be effected; (2) that the signing of the judgment had been wrong, as there had been delay and no proceedings had been taken for more than a year after the issuing of the writ; and (3) that the damages were excessive. As to the first point, it was contended that substituted service could only be allowed where it would have been but for particular circumstances possible to have effected personal service, which was not the present case, the defendant being a foreigner, residing out of the jurisdiction, and having never been within the jurisdiction. Formerly there had been service out of the jurisdiction in cases of tort, but now it was only allowed in the cases enumerated in Order XI., and the present one was not one of them.

Sir HENRY JAMES, Q.C. (with whom was Mr. Pollard for the plaintiff), said that in the present case there had been no application for service of the writ out of the jurisdiction.

Sir CHARLES RUSSELL said that no doubt that was the case. He should, however, contend that if the order made in the case had been right there could be substituted service on a man who could not be served personally. The learned counsel cited "Sloman *v.* Government of New Zealand" (1 C. P. D., 563), "Flower *v.* Allen" (33 *L. J.*, Ex., 83), and "Hesketh *v.* Fleming" (24 *L. J.*, Q. B. D., 255). As to the signing of the judgment that had been wrong, because there had been delay and no proceedings for more than a year after the issuing of the writ, and therefore notice ought to have been given (Order LXIV., Rule 13, and "Webster *v.* Myer," 14 Q. B. D., 564). On the point as to the damages having been excessive, the learned counsel said that the statement of claim had never been brought to the notice of the defendant Bennett, and the endorsement on the writ had simply been "The plaintiff's claim is for damages for libel." The case had been treated before the Under-Sheriff as if it had been one of judgment in default of plea, while it really had been one of judgment in default of appearance. The jury ought not to have been allowed to take into consideration the damage alleged by the plaintiff to have been done to him in America as well as in this country.

Mr. POLLARD said that the point which he had made as to this in the Under-Sheriff's Court had been that the plaintiff sought redress for the injury done to him by the defendant by having sent over false intelligence by his own cable to be published in his newspaper at New York.

At the hour of adjournment the arguments of the learned counsel for the defendant had not been brought to a conclusion, and the further hearing of the case was postponed until Wednesday.

Wednesday and some part of Thursday were occupied with the discussion whether the judgment should be set aside on the ground of irregularity, the defendant not being a British subject. After lengthened arguments on either side, Lord Chancellor Coleridge decided that the Court must have time to consider their judgment.—Judgment accordingly postponed.

Edison and Swan United Electric Light Co. (Limited) v. Holland and the Jablochkoff and General Electricity Co. (Limited).

This was an action brought before Vice-Chancellor Bacon to restrain an alleged infringement of the plaintiffs' patents of incandescent lamps by an electric installation at the Albert Palace, Battersea, of which the defendant, Mr. Wm. Holland, is the manager. The action now came on upon a motion by the plaintiffs for an injunction until the trial. In consequence of the recent judgment of Mr. Justice Butt (already reported in *The Electrician*) pronouncing in favour of the validity of the plaintiffs' patents, the defendants now submitted to an interim injunction restraining them from buying any more lamps except from the plaintiffs, and to keep an account until the trial, with liberty to apply, in case of Mr. Justice Butt's decision being reversed on appeal. It was stated that the plaintiffs had arranged to take the injunction in this form to obviate any inconvenience to the public visiting the Albert Palace. The Vice-Chancellor also made an order, upon the application of the defendants, the Jablochkoff Company, adding the Anglo-American Brush Electric Light Corporation (Limited) as defendants, they being the manufacturers of the lamps supplied by the Jablochkoff Company to the defendant Holland, and having entered into an agreement with the Jablochkoff Company to indemnify them against the litigation. The Attorney-General (Sir R. Webster, Q.C.), Mr. Aston, Q.C., Mr. Moulton, Q.C., and Mr. Bremner appeared for the plaintiffs; Sir H. Davey, Q.C., Mr. Marten, Q.C., Mr. Renshaw, and Mr. Graham for the defendants.

COMPANIES' MEETINGS.

The Cuba Submarine Telegraph Company (Limited).

The thirtieth ordinary general meeting of the Cuba Submarine Telegraph Company (Limited) was held at the Company's offices, No. 61, Old Broad-street, on Wednesday, the 11th August, 1886, under the presidency of Mr. Joaquin de Mancha.

The SECRETARY (Mr. James Scott) read the notice convening the meeting, and the report of the Directors and statement of accounts were taken as read.

The CHAIRMAN then said: Gentlemen, before asking you to pass the report and balance sheet, perhaps you would like to hear a few words from me. During the last six months we have had rather an anxious time, as you will remember when we last had the pleasure of meeting you we were threatened with the laying of a new cable between Halifax and Jamaica.

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That, as you see by the report, has now been abandoned, and the Government only intend to lay it as far as Bermuda. That being so we shall not be at all injured. That, therefore, is a circumstance off our mind, and I need not say that we were very pleased that the Government came to such a resolution. We then heard of a new cable that it was proposed at one time to lay between the Canaries and Cuba. That also caused us some little anxiety, and we wrote our agent in Madrid asking him to make inquiries, and I am glad to inform you that the Government has not sanctioned this cable, which was another anxiety removed from our minds. Then it came about that our receipts were being diminished. As you will have seen by the report, unfortunately our earnings, compared with those of the same period of last year, have diminished by about £1,700. But, as you are all aware, in every branch of business there has been great depression, and we unfortunately have suffered somewhat, though not to the extent that might have been anticipated. Notwithstanding all these difficulties, which, I am glad to say, have been overcome, and after repairing the cable from Batabano to Cienfuegos, which, unfortunately, has cost us nearly £3,400, we are able to propose to you a dividend at the rate of 8 per cent. per annum on the ordinary shares. Taking into consideration all the difficulties that we have had to go through during the last six months, I hope that that will be considered satisfactory by the shareholders. In paying this we have not trenched at all upon our reserve fund. You will find by the accounts that it is exactly the same as it was before. The only thing that we have had to do has been to trench a little upon the interest. You will see that we have passed the balance of interest account, £1,670, to revenue, and by that means we are able to keep up our dividend, and carry forward £600 to the next half year. I think, taking everything into consideration, that our shareholders must be satisfied with the result. I am glad to inform you that the prospects for the present six months are a little better. I think our increase in July has been about £300 more than there was at the same period last year. We hope that the improvement may continue, and that when we meet you six months hence we shall be able to give you a more favourable report than that now placed before you. With these remarks I beg to move, "That the report and accounts now submitted be received and adopted."

Mr. ALEXANDER F. LOW seconded the motion.

Mr. GRIFFITH: It is generally a pleasant thing to meet the Directors of this Company, for the report that they present is usually one that is very satisfactory and gratifying. While other companies are complaining I think we have cause to rejoice. While the dividend of other companies has been falling off, and notwithstanding that our own business has fallen off a little, I think a dividend of 8 per cent. will satisfy most of us. Had it not been for that unfortunate accident on the Batabano-Cienfuegos cable, I have no doubt that the dividend would have been much larger. We reciprocate the sentiments that you have uttered, and think that we are indebted to you for your able management of this Company. We all take an interest in everything that can promote its success, and looking at the balance-sheet from a mere legal point of view, I think I can possibly make a suggestion. I see we pay a large sum by way of income-tax. I have to inquire whether that income-tax is paid on preference as well as on ordinary shares?

The CHAIRMAN: We deduct it from the preference shareholders, but we do not deduct it from the ordinary shareholders.

Mr. GRIFFITH: I was going to make the remark that in some companies it has been usual to pay the income-tax on preference shares. I am speaking now as the auditor of one of our large companies. They have been taking legal advice on the subject, and have found that they are not bound to pay the income-tax for the preference shareholders. The preference shareholders have merely a preferential claim to their dividend, but any money beyond that is not to be paid at the expense of the ordinary shareholders, but is to be paid at the expense of the preference shareholders themselves. This may possibly vary in particular companies, owing to the particular terms of their constitution. But I think it is pretty clear that the ordinary shareholders should not bear the expense of the income-tax for the preference shareholders.

The CHAIRMAN: If you had read the accounts you would see that we deduct the income-tax from all gentlemen who are preference shareholders, but on the ordinary shares we pay it ourselves. Not only so, but I think I may add that we are so conscientious that the Directors themselves pay income-tax on their remuneration, which I do not think is usual in other companies.

Mr. LOW: And the auditor's as well.

The resolution was then put and carried unanimously.

The CHAIRMAN next moved "That the following dividends for the half year be now declared on the shares of the Company, namely, at the rate of 10 per cent. per annum subject to income-tax on the preference shares, and 8 per cent. per annum free of income-tax on the ordinary shares payable on and after to-morrow."

Mr. LOW seconded the resolution, which was carried unanimously.

The CHAIRMAN: Mr. Low goes out of office by rotation. He is one of the original Directors of the Company. I have had the pleasure of serving with him for many years, and I have great pleasure in recommending his re-election.

Mr. COCHRAN seconded the resolution, which was agreed to *nem con.*

On the motion of Mr. COCHRAN, seconded by Mr. SQUIRE, the auditor of the Company, Mr. Thomas Greenwood, was also unanimously reappointed.

A SHAREHOLDER asked how the new commercial treaty with Spain was likely to affect the Company.

The CHAIRMAN: Anything that takes off the trammels from commerce is sure to be good for commerce generally. I think that with this new treaty with Spain there will be more interchange between Cuba and Spain, which ought to bring us a little business.

Mr. COCHRAN: I know something of Cuba, unfortunately, and I do not think Spain can do much worse for Cuba than she has done in the past. The only difficulty that I anticipate will be this movement in regard to the manumission of slaves. This labour question has really been a substantial difficulty because of the reckless way in which Spain has managed that colony by sending out officials and keeping a large staff who were not administering the affairs honestly and fairly.

The CHAIRMAN: I think before we part I should wish you kindly to second me in giving our thanks to Mr. Keith for the very efficient manner in which he carried out our repairs. In a company of this description we are so liable to have breakages that it is very essential that we should have a good man to call upon at any time. The moment we knew that the cable was interrupted we telegraphed to Mr. Keith to hire a steamer and to repair it himself. He did so very efficiently; and not only that, but he recovered at the same time a great portion of original cable that was laid down, which according to our estimate is worth about £1,000, so that we have repaired the cable without encroaching upon our reserve fund. In this vote I should like also to include Mr. Scott and the other members of the staff. Those who have any intercourse with Mr. Scott know how ready he is to give every information in regard to the Company, and how zealous and assiduous he and the other gentlemen who support him are in performing their duties.

Mr. LOW having seconded the motion, it was carried unanimously.

The SECRETARY briefly acknowledged the compliment.

A SHAREHOLDER then proposed a vote of thanks to the Chairman and the other Directors, which was cordially passed.

The CHAIRMAN: I have, on behalf of my colleagues and myself, to thank you for the honour you have done us in according to us your thanks for our management of the Company. I can only repeat what I said before, that we are always ready to do what is required in the interests of the Company, and it encourages us to be more diligent, if possible, to know that we have your approval.

The proceedings then terminated.

The National Telephone Company.

The sixth annual ordinary general meeting of the shareholders of this Company was held at the Company's offices, 11, Queen Victoria-street, on August 6, under the presidency of Colonel R. Raynsford Jackson.

The SECRETARY (Mr. Wm. B. Campbell) read the notice convening the meeting.

The report, which appeared in *The Electrician* of last week, was taken as read.

The CHAIRMAN: Gentlemen, in moving the adoption of the report I shall have but few remarks to address to you. I will recall to your recollection, in the first instance, that on the 11th of August last year you authorised the Directors to issue £150,000 in Second Preference shares. I have now to announce that all those shares have been taken up by the public. Then I wish to call attention to one paragraph in the report which gives the annual rental at £80,674. 2s. 8d., and I want to explain that that is not the whole of the revenue of the Company, because another revenue outside the rental revenue has been rapidly developed in the last eighteen months. It is that derived from fee messages. On the 1st of January, 1885, the amount received from fee messages was £4. 18s. 2d; in June in the same year it had risen to £39 7s. 11d.; in January this year it amounted to £49. 1s. 10d., and in June to £68. 11s., so that there is a revenue which has not been shown in the report to an amount between £800 and £900. Therefore the total revenue, including rentals and fee messages, was on June 30th £81,500. I will next call your attention to the trunk wires. We have extended our trunk wire system considerably. Glasgow, for example, is in communication with a large number of other towns, and the inhabitants of Glasgow and those towns can communicate with each other either by paying annual rental or the small fee of 6d. per conversation lasting three minutes. I have before me a little sketch of our Glasgow trunk wire system, which it may interest some of you to glance at. It is from a plan that is issued to our subscribers in Glasgow, that they may know how to take advantage of our trunk line system. I may mention, however, that the connection between Glasgow and Edinburgh is not shown there. At present we are depending upon the Post Office for the trunk wire between those two cities. We have also from the Post Office trunk wires between Glasgow and Greenock, and Glasgow and Paisley. We have an engagement with the Post Office, which lasts to the 30th September next year, when we shall be entirely rid of our trunk wire contract with the Post Office, and shall depend upon our own trunk wires exclusively for giving the service to Glasgow, Edinburgh, and the whole of the wealthy industrial parts of Scotland embraced in the district between those great towns. While I am on the subject of trunk wires, I am happy to be able to state that our Company has made an arrangement with the Lancashire and Cheshire Company, by which the industrial towns of Yorkshire are in communication with the large manufacturing and other important centres in Lancashire. The connections are completed, conversations have taken place over the wires, and in the course of a few days the public will have the free use of the advantages which we are able to give as the result of the arrangements between the two companies. Another advantage we have given to the public is that of call boxes. In Glasgow we have as many as twenty-two of them, and our subscribers use them free of charge. Those who are not exchange subscribers use them on a payment of a fee of 3d. That is found to be a great advantage, both to our subscribers and the general public in the centres where the call box is introduced. In many cases we use an automatic call box. The person using it just drops in 3d. and puts himself

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automatically in communication with the exchange. He is then connected with the subscribers with whom he wishes to hold a conversation. We have, during the year, opened nine new exchanges, and we are now busily at work starting several others, besides examining the country with the view of obtaining the necessary way-leaves to still further extend our system. That extension is giving to those who have hitherto not had the advantage of the telephone the power of using it, and our aim will be as far as possible to connect all the smaller towns with such important centres of industry as it may be desirable for their inhabitants to hold communication with. It has been the custom of the Directors to make some reference in the report to the relations between the Company and the Post Office. We hold the licence under which we work from the Postmaster-General, and we have had various subjects under discussion with that department from time to time, but we have arrived at such a state of chronic amicability in our relations with the Post Office that it is now no longer necessary to introduce a special heading into our report bearing upon that subject. I am happy to be able to inform the shareholders that our relations with the Post Office are about as satisfactory as they well could be. Whilst dealing with this subject there is one point which I wish to remark upon, and it is this—that I think very great additional advantages might be given to the public with benefit to the Post Office, and without grave disadvantage—perhaps it would be somewhat of an advantage to the telephone companies—if the telegraph and the telephone in all parts of the country were connected with each other, and if the subscribers to the telephone companies were enabled through the telephone to communicate with the Post Office, in order to send messages to all parts of the world, receiving their replies through the same double instrumentality, the telegraph and the telephone. As far as the National Telephone Company is concerned, it would be quite prepared to give to its subscribers the benefit of this connection without charge, if the Post Office would allow the Company to connect the postal telegraph with the various exchanges without making any charge to us. I think they might do this, because I am quite convinced that a great increase of telegraph revenue would follow an arrangement of this kind. Gentlemen, I do not think it necessary to dwell upon any other features in the report, or to occupy your attention any longer. I make it a rule never to indulge in prophecy with reference to the prospects of the Company. I think it is sufficient that at the end of each year events should speak for themselves. I will, therefore, content myself with proposing the adoption of the report and accounts.

Mr. JOHN BRUCE seconded the motion, which was carried unanimously.

The CHAIRMAN: As you see by the last paragraph but one in the report, three of our directors retire and offer themselves for re-election. The first in the list is Mr. W. Hardwicke Bradbury, and I have great pleasure in proposing that he be re-elected a Director of the Company. It is not necessary for me to say anything in eulogy of Mr. Bradbury, for I think I may say that it is a source of satisfaction and advantage to the shareholders that the Directors of the Company have paid persistent, valuable, and steady attention to the affairs of the Company.

Mr. CARGILL seconded the resolution, which was carried unanimously.

On the motion of the CHAIRMAN, seconded by Mr. BRUCE, Mr. W. Lowson was re-elected to his seat at the Board, as was also Mr. Samuel de la Grange Williams, on the motion of the CHAIRMAN, seconded by Mr. W. A. SMITH.

Mr. CARGILL next moved, and Mr. TIMBERLAKE seconded, the re-appointment of the Company's auditors, Messrs. Quilter, Ball, and Co., which was agreed to.

The CHAIRMAN: I beg to move—"That Article 62 of the Articles of Association be amended by omitting the words 'fifty preference shares of the original capital of the Company,' and substituting for the same the following words: 'fifty first preference, or one hundred second preference shares, or five hundred ordinary shares of the Company.'"

Mr. CARGILL: What is the object of that?

The CHAIRMAN: The object is this: The United Telephone Company is entitled to have two Directors upon our Board, and it is a very large holder of ordinary shares. It is the wish of the United Telephone Company that its Directors should be entitled to qualify with ordinary shares instead of preference shares. I thought it would be better to give a wider range of qualification to all our shareholders, and to enable the first preference, and second preference, and the ordinary shareholders to act as Directors if selected for the purpose.

Mr. BRUCE seconded the motion, which was agreed to *nem. con.*

The CHAIRMAN: You will recollect that at our last meeting there was some difference of opinion as to whether the dividend resolutions ought to be passed by the shareholders. It has never been the custom of this Company to propose such resolutions, and we were advised by our legal advisers that it is not necessary. The Directors have power under their articles to declare the dividend, and the shareholders, by passing the report, approve of the policy indicated in the report with reference to the dividends, so that by implication, at all events, the shareholders, by passing the report, approve of the dividends. But if it is the wish of the shareholders that we should adopt the plan, that is common in some companies, of proposing resolutions on the subject, I have no objection to doing so. I propose, therefore, "That a dividend at the rate of 6 per cent. per annum, less income tax, be paid on the first preference for the six months ended June 30th."

Mr. BRUCE seconded the resolution, which was agreed to unanimously.

On the motion of the CHAIRMAN, seconded by Mr. SMITH, it was further resolved, "That a dividend at the rate of 6 per cent., less income tax, be paid upon the amount called up on the second preference shares for the six months ended June 30th," and, "That a dividend at the rate of 3½ per cent., free of income-tax, be paid on the ordinary shares for the six months ended June 30th.

Mr. SMITH then proposed a vote of thanks to the Chairman. They had, he said, heard from Col. Jackson how the Company had progressed during the last year, and perhaps it would not be amiss for him (the speaker) to say that a very large proportion—in fact, he might say the entire prosperity of the Company was due to Colonel Jackson's personal efforts. It was astonishing to find that a Company which only four years ago had a surplus revenue of £144, should now have £17,500 to dispose of, and he might say at once that, in his opinion, and in that of most of his colleagues, the great bulk of the credit for the condition of their affairs was due to their Chairman. He therefore asked the shareholders to join him in giving a hearty vote of thanks to that gentleman for his unwearied efforts on behalf of the Company. The Chairman had referred to one or two important features of the Company, but he (Mr. Smith) thought it was also encouraging to know at the end of the half-year that in addition to their larger revenue they had more orders in hand.

Mr. CARGILL seconded the motion, endorsing the remarks of the previous speaker.

The resolution having been cordially passed,

The CHAIRMAN said: I must necessarily feel greatly gratified by the manner in which you have passed the resolution proposed by Mr. Smith, as I also am by the language in which he introduced it to the meeting. But, for my part, I cannot take so large a share of the credit for our prosperity as Mr. Smith and Mr. Cargill are willing to give me. When I was called upon to organise this Company an important question for consideration was whether the Directors were to be gentlemen resident in London, or whether they were to be elected on account of the influence they possessed in the various centres in which we were going to work. I thought the latter the right plan, and the Company has got invaluable aid from the various Directors of the Company in the different districts where they happen to reside, and especially has that been so in the Glasgow district, which is largely indebted to Mr. Smith for the great development that has been made in revenue there. It is now close upon £25,000 a year in Glasgow, and its immediate dependencies. I recollect when, at an early meeting of the organisers and promoters of this Company and of a number of gentlemen connected with the United Telephone Company, having resorted to the usual custom of Englishmen when they want anything to be successfully carried out of dining together, and the question being mooted what would probably be the extent of the development of the revenue of the Company in Glasgow—then at a very small figure—Mr. Smith created a great deal of amusement by saying that Glasgow would be good for from £20,000 to £30,000 a year. Mr. Smith's prophecy has been realised in five years from the time when he made it. I see no reason to doubt that another prophecy, which I shall not divulge to-day, but which was made to me lately, may also be justified by eventual circumstances. I have also, as I have said, the assistance of other directors in important centres. One of my colleagues who resides in Yorkshire, for example, gives very great attention to the interests of the Company in that district. Mr. Bruce has done a great deal in Edinburgh, Mr. Lowson in Dundee, Mr. Williams in Birmingham, and Mr. Sands in Nottingham, so that the Company is largely indebted to Directors, who are willing to give me a much greater share of the credit for the progress of the Company than I can properly and conscientiously take to myself.

The proceedings then terminated.

South of England Telephone Company (Limited).

The second ordinary general meeting of this Company was held on Monday, the 9th inst., at Winchester House, Old Broad-street, under the presidency of Mr. David Owen Bateson, the Chairman of the Company.

The SECRETARY (Mr. Fred. L. Robinson) read the notice convening the meeting.

The CHAIRMAN: I am very sorry that our meeting has been so long delayed; but there are several reasons why this has occurred this year. Our books and papers—it being a new Company—required a great deal of consideration before we could decide as to how they could best be kept. Again, we did not have sufficient accommodation for our staff, and we could not get on with our business so fast as was wished. But I see no reason why in future years we should not have our meetings six weeks after each year has expired, and we shall, at all events, do our best to promote that end. I have to apologise for the absence of my good friend, Mr. Campbell, one of the directors, who has been obliged to go to Paris on family matters, and Mr. Morgan is also absent. It is unfortunate that the meetings of the Northern District Telephone Company and of our Company were fixed for the same day. Mr. Morgan has been obliged to go to Sunderland to attend the former meeting, which, I suppose, more required his attendance than our own, and is, so far, complimentary to us.

I hope, gentlemen, you will make every allowance for me, placed, as I was, so suddenly and unexpectedly by the death of Mr. Kendal, in the chair of the Company. You know what an exceedingly difficult man Mr. Kendal was to succeed. He was a man of very great intelligence, wonderful business aptitude, and enormous energy, so far as his health would admit. He also possessed the talent for expressing himself clearly in vigorous and idiomatic English—a qualification in which I much fear your new Chairman is lamentably deficient. We all regret his death exceedingly, and I assure you no one more than I, who am obliged very unworthily to fill his place. I hope you will bear with me while I explain, as far as I can, the position in which the Company is placed, and I trust that you will not institute any invidious comparisons between your two Chairmen, which I know will not redound very much to my advantage.

It is fortunate for me that I have nothing to apologise for or explain away. The success of our Company has been as great as we had any reason to anticipate. Some of our more sanguine share-

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holders seem to have had visions of a dividend upon the ordinary shares this year, but I think that is extremely unreasonable. They apparently forget that it is the first year of our existence, that we commenced with nothing or next to nothing—with a capital of only £6,433. The figures show that we began with three exchanges, and that we end with 18. We began with 116 exchange subscribers and 123 private lines, and at the end of the year we had 687 exchange subscribers and 248 private lines, and I am happy to say that though, considering our youth, we have attained a pretty fair size, yet like the celebrated Irish giant, we are still growing. Since the close of our financial year our exchange subscribers have reached 820, and our private lines 276, while our new orders for the past three months have been £1,500. I think you will agree with me that we have not been absolutely idle. We have progressed gradually, and we fancy we can discern in the not dim or distant future a dividend on the ordinary shares. We have paid two half-yearly dividends on the preference shares, and have transferred £3,700, the unearned increment of our rentals, to the present year, and we carry forward a balance of £727. These two items are almost 1½ per cent. on the ordinary capital. Of course we could not divide these sums, but they stand to the credit of the Company, and they are a nice little nest egg to begin the new year with.

These results, however, have not been brought about without a great deal of hard work and constant attention. When the reins fell from the dead hand of Mr. Kendal, I was somewhat nervous at taking them up, but it is one of the advantages of a small Board that each and every member is fully aware of all that has been going on, and in our case the transfer of authority was effected without any pause in the business, and without the slightest friction. I say I was somewhat nervous, and hardly think I would have undertaken the office had I not known that I should have the loyal assistance of my good friend Mr. Campbell, who would have made a far better Chairman than I can pretend to be. His other avocations, however, would not admit of this. I knew also that Mr. Morgan, with his extensive experience of telephonic business, was always at my command in case of any serious difficulty, which, however, happily, has not arisen. I may add, too, that our new Director, Mr. Alex. Macgregor, brings an amount of technical knowledge to the service of the Board which is extremely valuable. The short time he has been with us has been long enough to show that he will be a most useful and intelligent member of the Board. I beg also to add a word of thanks to our indefatigable and hard-working secretary (Mr. Robinson). He has all the routine of the business at his fingers' ends, and without his knowledge the Directors would many a time have been very much at a loss. But, gentlemen, there is a great deal of the management of a concern such as ours which only the Chairman or Managing Director can undertake. There is an immense mass of detail which he has to master, and a great variety of minutiæ which he has to get into his head, and which can only be put there and kept there by day-by-day attendance at the office and constant supervision of the work going on. Since I have had charge I have made it my business to be at my post every day. I have hardly been away at all, except when I have been visiting our stations seeing that all was being done there in a satisfactory manner. In all my efforts I have had the countenance and support of the other members of the Board. We all resign our seats to-day in accordance with the Articles of Association. If you see fit to re-elect us, we are willing to continue to do our duty to the shareholders, or if you decide otherwise, we shall hand over our offices to our successors, who will find, I think, the affairs of the Company in perfect working order.

Now, with regard to finance, it was the opinion apparently of our late Chairman that the business of the Company could be satisfactorily carried on with a very small capital indeed. In this the other members of the Board, myself included, rather differed from him, but as he took such an immense interest in the well being of the concern, and held such a large proportion of the ordinary shares, we deferred to his opinion, being pretty well assured that the time would come when he would be compelled by circumstances to alter his views. But we regret to say he did not live to see this time come. Our business has increased so rapidly that it has already absorbed all our originally called-up capital, viz., £6,433, and we have been compelled to borrow £2,000 and to call up 10s. per share on our first issue in order to keep ourselves going. It is somewhat unfortunate, as we now see, that we only issued so small a portion of our preference shares, and it is now our wish to float the balance, say, 13,567 shares, calling up £1 per share in conformity with the original prospectus. Of course you are aware that one ordinary share is by that prospectus attached to each preference share, and the late Mr. Kendal bound himself by a formal agreement to furnish the Company with one ordinary share to be allotted to every person who should subscribe for each preference share. A difficulty, however, has arisen with the representatives of the late Mr. Kendal as to handing over these shares, they contending that they are absolved from this agreement in consequence of the whole of the shares not having been allotted immediately on the issue of the prospectus. I do not think they have a leg to stand on in this contention; but the result is that our way is in a measure stopped, and the extension of our business may be retarded until such time as the matter can come before the legal tribunals, which now cannot be until November. This is very unfortunate; and, unless we make some financial arrangement, I do not see how we can get on. I trust, however, we shall be enabled to do this, as it would be a monstrous pity to have such a very promising business as ours jeopardised. We trust that the Messrs. Kendal will come to a better frame of mind ere long, so as to enable us to offer the preference shares, together with the ordinary share attached, as set out in the prospectus. When the time arrives due notice shall be given. I may add that we have already had application for a large number of our preference shares, which we have been unable to allot for the reasons before stated.

I have now to move that the report and accounts for the fifteen months ending 30th April, 1886, now presented, be adopted and passed.

Mr. A. MACGREGOR seconded the motion.

Mr. TAYLOR observed that the progress to which the Chairman had referred—£1,500 for the past three months—was at the rate of £6,000 a year.

The CHAIRMAN: Yes, but we hope it will be more I do not, however, think that that rate of progress is altogether unsatisfactory.

Mr. PARRISH said that the Company had started in a very fair and prosperous manner, particularly as they are working on comparatively barren ground—that is, ground where there are no large commercial centres, as in Lancashire or in the metropolis. He therefore thought the report and accounts very favourable indeed. As he noted that there was nothing in the accounts to represent the remuneration of the Directors for the past fifteen months, he had great pleasure in proposing that their remuneration should be £250 for that period.

Mr. TAYLOR seconded the motion, which was unanimously passed.

The CHAIRMAN: On behalf of the Board, I beg to thank you for this vote. The amount is more as a recognition of our services than as a reward for our labours. We will hope in future years, when we pay you a dividend on the ordinary shares, you may see fit to review this amount; but we shall do our duty to the Company whatever is voted to us.

Resolutions were afterwards passed re-electing the following gentlemen to their seats at the Board—Messrs. D. O. Bateson, T. F. Campbell, and A. Macgregor,

The CHAIRMAN, in answer to a question, stated that Mr. Morgan was nominated by the United Telephone Company.

Mr. J. WEISE, of the firm of Messrs. Turquand, Youngs, and Co., was re-elected auditor, with a remuneration of 40 guineas.

Mr. GRIFFITHS then proposed a vote of thanks to the Chairman and Directors. He warmly acknowledged the services of the Chairman, whose kind remarks respecting the late Mr. Kendal would be appreciated by the deceased gentleman's relatives, whom he (Mr. Griffiths) was representing at the meeting.

The motion was carried unanimously.

The CHAIRMAN having briefly acknowledged the compliment, the proceedings terminated.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. AUG. 11.		BUSINESS DONE WEEK ENDING AUG. 11. Highest.		Lowest.	
Anglo-American	33,	34	.....	33½	.....	32
Do. Preferred	54½,	55½	.....	54½	.....	53
Do. Deferred	10¾,	11¼	.....	11¼	.....	10¾
Brazilian Submarine	10½,	10½	.....	10 7-16	.....	10 5-16
Cuba	11½,	11¾	.....	11½	.....	11½
Do. Preference	18½,	19½	.....	—	.....	—
Direct Spanish	1½,	2	.....	—	.....	—
Do. Preference	9,	10	.....	—	.....	—
*Direct United States Cable	8⅞,	9⅛	.....	9 1-16	.....	8 15-16
†Eastern Telegraph	11,	11¼	.....	11¼	.....	10¾
*Do. 6 per Cent. Preference	14½,	14½	.....	14½	.....	14½
*Do. 5 per Cent. Debentures, 1899	105,	108	.....	—	.....	—
Eastern Extension	12,	12¼	.....	12¼	.....	12
German Union	9¼,	9¾	.....	—	.....	—
Globe Telegraph and Trust	6½,	6¾	.....	6 5-16	.....	6 3-16
Do. Preference	13½,	13½	.....	13½	.....	13 3-16
Great Northern	12½,	12⅝	.....	12⅝	.....	12 7-16
Indo-European	35½,	36½	.....	—	.....	—
Reuter's	6,	6½	.....	6½	.....	—
Submarine	200,	210	.....	200	.....	—
West India and Panama	⅝,	¾	.....	¾	.....	—
Do. 1st Preference	8¾,	9½	.....	9½	.....	9
Western Brazilian	6¾,	7	.....	7	.....	6¾
Western Union 7 per Cent. 1st Mortgage	118,	122	.....	121	.....	—
Do. 6 per Cent. Sterling Bonds	103,	107	.....	—	.....	—

TELEPHONES.

Consolid. Telephone and Maintenance	13-16	15-16	.....	—	.....	—
Oriental	3-16	5-16	.....	3-16	.....	—
United Telephone	13⅜,	13⅝	.....	13¾	.....	13 7-16

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	2,	2½	.....	2⅝	.....	—
Do. (fully paid)	3¾,	4¼	.....	—	.....	—
Swan	⅞,	1⅛	.....	1	.....	—
Maxim-Weston	3-16	5-16	.....	—	.....	—

MISCELLANEOUS.

Telegraph Construction	37½	38½	.....	38	.....	—
*India Rubber, Gutta Percha, and Telegraph Works	22½	23½	.....	23½	.....	23½

* x.d. † x.d. and bonus.

TRAFFIC RECEIPTS FOR JULY, 1886.

COMPANIES.	July, 1886.	July, 1885.	Increase.	Decrease.
Cuba Submarine	2,800	2,517	283	—
Direct Spanish Telegraph	1,270	1,284	—	14
Eastern Extension	34,931	46,099	—	11,168
Eastern Telegraph	43,708	48,081	—	4,373
Great Northern	23,000	—	—	—
West Coast of America	3,050	—	—	—

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NOTES.

NIAGARA FALLS INSTALLATION.—The Niagara Falls are now furnishing power for about 100 arc lights. The number will shortly be largely increased.

THE VAN RYSSELBERGHE SYSTEM.—It is announced that the employment of the Van Rysselberghe system is to be still further extended in Germany.

DOMFRONT.—The town of Domfront is shortly to be the scene of a magnificent *fête*, on the occasion of the introduction of a permanent street lighting installation by electric light.

THE BELL TELEPHONE COMPANY.—This company has entered two more actions for infringement; one against the "Cushman" Company, the other against the "Inter-State" Telephone Company.

AMERICAN ELECTRICIANS.—The National Electric Light Association of America will hold its next meeting at Detroit, at the end of the present month. Some very interesting papers are expected to be forthcoming.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended the 15th Aug. are £1,669, as compared with £2,191 in the corresponding period of 1885.

EDINBURGH TELEPHONE EXCHANGE.—We have received a copy of the Edinburgh Telephone Exchange list of subscribers; the total number of connections is now about 500. We notice that the number of subscribers to the Glasgow trunk line remains very small.

CELLULOSE.—The usual solvent employed in the treatment of cellulose is an ammoniacal solution of sulphate of copper. It is now stated that when cellulose is employed for the filaments of incandescent lamps it is preferable to employ as a solvent a neutral solution of zinc chloride.

JUMPING TO A CONCLUSION.—On the basis of a note which we recently published as to the lighting of a church in Durham, we are informed by a French contemporary that "electric lighting is making *très grande progrès* in the churches of England." We wish that this were a little nearer the truth.

MONTREAL.—The gas company in this city refuses to make way for the electric light. The main thoroughfares are now illuminated by both arc lamps and gas; but the municipality refuses to pay for the latter, which was ordered to be discontinued some time since. The gas company has therefore commenced a law-suit against the corporation.

THE EDISON-SWAN COMPANY.—The *employés* of the Edison-Swan Company had their annual excursion on Saturday last. The company proceeded by an early train to Dover, where a very pleasant day was spent, substantial fare being provided at the Royal Oak Hotel. The weather being favourable the outing was much enjoyed by all who took part in it.

COREA.—The King of Corea is an enlightened monarch. He not only takes an interest in the progress of physical science, but his æsthetic taste is also highly cultivated. He has recently ordered from the Edison Company of New York an incandescent plant, including a very beautiful vase of Bohemian glass filled with artificial flowers and illuminated by a number of small lamps.

ANOTHER CITY INSTALLATION.—We are informed that an office in No. 16, Austin Friars has been for the last fortnight lighted by means of six Edison-Swan lamps of 20, 10, and 5 candle-power. The current is furnished from a Regent primary battery. The installation was carried out by Messrs. Swete and Main, 11, Queen Victoria-street, City, and has so far given entire satisfaction.

SOME NEW INSTALLATIONS.—We understand that Messrs. Faraday and Son, of Berners-street, have lately furnished the designs and fittings for the following amongst other recent installations:—At the residence of Sir Arthur Sullivan; at a chateau in Belgium; for a new theatre at Algiers; for extension of existing installations at Messrs. Shoolbred and Co.'s; and at the British Museum.

PHILADELPHIA. — Wherever the electric light is most familiarly known it may safely be said that it is there most highly appreciated. An illustration of this fact comes from Philadelphia, where the inhabitants of Susquehana Avenue have petitioned the municipality to supply them with arc lights, and have volunteered to pay the first cost of the installation if the maintenance is thrown upon the rates.

A HIGHLY REMARKABLE RESULT.—One of our French contemporaries, whose name we forbear to mention, in the course of an elaborate article upon a new form of a very old battery, states that "the great advantage possessed by the cell is that by suitably varying its shape and size the strength of the current can also be varied at will." We trust that the inventor will not succeed in obtaining a patent for this "peculiarity."

TEMESVAR.—It will be remembered that the town of Temesvar in Hungary was provided rather more than twelve months ago with a very large installation consisting of glow lamps arranged in multiple series and supplied by high tension machines driven by water-power. Since then, although the light has been in successful operation, the total consumption of gas has undergone no diminution—a striking result which is, however, the rule rather than the exception.

MAGNETIC FORCE LINES.—A bowl is filled with water and lycopodium strewn on its surface, the superfluous powder being afterwards blown away. The bowl is then placed in the spot whose magnetic field it is wished to investigate, for example, at the pole of a magnet. Very fine iron powder is then allowed to fall into the bowl from some height. On slightly shaking, the forms of the force lines form on the surface of the water by means of the iron powder borne by the lycopodium.

POLICE TELEPHONE SERVICE.—In Brooklyn, Chicago, and some other American towns there is now being introduced a system of street telegraph and telephones for the use of the police. The instruments are erected in suitable iron boxes placed at convenient intervals, and each policeman possesses a key. The telephone is in direct communication with the nearest police station, and there are also special signals provided for summoning assistance in cases of riot, accidents, fires, &c.

ELECTRIC LIGHT AT TEHERAN.—Mr. Stevens, the bicyclist, who is attempting to ride round the world, has written to a contemporary from Teheran giving an amusing account of the effect produced upon the native mind by the arc lights which the Shah has recently had placed in the square of the palace. It is the lighting up that astounds them most of all. The general conclusion is that nothing but the direct instrumentality of Sheitan could produce an instantaneous illumination of such dazzling brightness.

VULCANISED FIBRE.—Vulcanised fibre is pure cellulose freed from all elements which are soluble in ordinary solvents, and from all volatile matters which are capable of ignition. It is absolutely uninflammable, and is not attacked by oils, benzine, fatty acids, alcohol, &c. Vulcanised fibre is made out of finely ground wood pulp, which is sub-

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jected in a closed vessel to a pressure of from 350 to 500 atmospheres, the lower pressure being employed in the manufacture of flexible, and the higher pressure in that of hard fibre.

THE PRESERVATION OF TELEGRAPH POLES.—It is stated that in Government contracts the only timber now employed for telegraph poles is the Baltic red-wood, well seasoned and then creosoted. To obtain the specified quantity of 10lb. of creosote injected per square foot the fine skin which grows underneath the bark must be carefully removed by planing. The processes which require the employment of salts of zinc, copper, or mercury have fallen into disuse, mainly on account of the solubility of these salts, and also owing to the rapid corrosion which they caused in the reservoir and apparatus used for injection.

DOMESTIC LIGHTING.—"Impney House," the residence of Mr. John Corbett, M.P., has recently been fitted with the incandescent light. Motive power is obtained from a turbine supplied with water from the River Salwarte under a fall of only 13ft. The machines are situated at a distance of about 250 yards from the house. Accumulators are employed, so that the current is always available. Full advantage has been taken of the æsthetic and artistic possibilities of the glow light, and some very fine specimens of venetian glass chandeliers are placed in the dining room, drawing room, and conservatories. The work has been carried out by Messrs. Nicholson and Jennings, of 759, Old Kent-road.

MEDICAL ELECTRICAL APPLIANCES.—At the meeting of the British Medical Association, held last week at Brighton, the "Electric Apparatus Company" displayed in the museum section an attractive exhibit of instruments showing the application of electricity to medicine and surgery. Among the apparatus which attracted most attention was an electric opthalmoscope, which is used for examining the eye by the aid of a small glow lamp, and is supplied with current from a specially designed "Victoria" battery. Several eye specialists spoke in praise of the arrangement. The company also exhibited a collection of "photophores," bullseye and head lamps, an electric cautery, together with induction coils and constant batteries.

TELEPHONES IN FRANCE.—The *Bulletin du Crédit* commits itself to the opinion that the greatest success of the scientific year is the domestic telephone, introduced by the Société Générale des Téléphones, under the name of "Téléphones et Microphones Domestiques Indéréglables." These telephones, we are informed, are now much used in place of the acoustic speaking tubes. From the *Paris Bourse* we learn that the Société Générale des Téléphones reports a considerable increase in the number of subscribers as compared with this time last year. On the 10th inst. the number of subscribers in Paris was 4,443, and in the Departments 2,199, making together 6,642, as compared with an aggregate of 5,834 on the corresponding date of 1885.

A SERIOUS BLUNDER.—The arrangements for giving an alarm of fire in the large towns of America, and for despatching the fire brigade with the utmost promptitude by the aid of various electrical contrivances, are usually supposed to have reached an almost phenomenal degree of perfection. At Boston, however, there has recently been afforded a melancholy illustration of the ease with which the most elaborate precautions may be frustrated by a little carelessness or stupidity. A fire having broken out in a large factory, the alarm was promptly signalled to the fire stations. Numerous engines and escapes immediately set out for the opposite end of the city, and in the meantime an unfortunate human being, who had climbed upon the roof of the factory, fell a victim to the flames. On an investigation it turned out that two distinct annunciators had each been labelled with the same number.

LIGHTING OF HARROGATE HYDROPATHIC ESTABLISHMENT. Harrogate is one of the very few towns where a certain local distrust of the electric light has lingered, owing to recollections connected with an installation of some years ago which was not altogether a success. Electric lighting has now got well beyond the stage where there can be any possible question whether a simple house lighting installation is or is not to be a success—at least, when the work is undertaken by properly qualified men. The Harrogate Hydropathic Establishment is now lit by incandescent light. The work has been carried out by the firm of Thompson, Dowsing, and Rew, and has given perfect satisfaction. The only special features of the installation are the ceiling plate holders, which are of novel design, and the special switches which have been introduced by the above firm, and which we described some time since.

THE TELEPHONE IN SUNDERLAND.—It appears, from what has fallen from Mr. T. Wilkinson, the chairman of the Telephone Company, that the extension of the system, which was at the outset of the operations of the company slow and tentative, has now become rapid and permanent. Within the last year trunk lines have been run from Newcastle to North and South Shields, and, in fact, the whole of Tyneside is now in communication with Sunderland, the Hartlepools, Stockton, Middlesbrough, and Darlington. It is easy to imagine the convenience this must be to business men, who at so small a cost are able to hold conversation with one another over such distances. In a three minutes' "talk" as much can be done as by a dozen telegrams, and, what is still more satisfactory, it is effected in a clear and rapid manner. The payment of a six per cent. dividend must be as gratifying to the shareholders as to the board of directors.

THE HOTEL DE VILLE, PARIS.—The Fine Arts Committee of the Municipality of Paris have just made a report with regard to the arrangements they recommend for providing the electric light at the Hotel de Ville. About 2,000 lamps are to be installed. The engine power at present provided only amounts to 130 horse-power, and this will be sufficient to do the work upon ordinary occasions. It is therefore proposed to provide dynamo machinery capable of supplying the whole of the lamps, and when on any special *fête* or reception they are all required at once it is arranged to obtain the additional power from one or more portable engines brought in for the occasion. For some reason not given, the Grande Salle Saint-Jeane is not included in this arrangement, but will continue to be lit with gas. In the interests of electric lighting nothing could be better devised than the contrast which will thus be afforded on the occasion of a "crush."

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.—The thirty-fifth meeting of the American Association for the Advancement of Science is now being held at Buffalo, New York, and will continue until Tuesday evening next. This is the third time that the Association has accepted an invitation to hold a meeting in Buffalo, the previous occasions having been at intervals of ten years. The city offers such excellent facilities for a gathering of this kind, both in its spacious auditoriums and hotels and its general accessibility from either the east or the west, that it has grown to be a favourite locality with the members, and a large assemblage has been assured. Special attention will be given by the section on geology and geography to the problems connected with Niagara Falls and its gorge. The retiring president, Prof. H. A. Newton, of New Haven, will deliver his address on the

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first evening of the meeting. The president is Prof. E. S. Morse, of Salem, Mass.

TURNBULL'S TELEPHONE TRANSMITTER.—This transmitter is now attracting some attention in the United States. It is put forward as being equally well adapted for short or long distance telephony, and that for the latter purpose it may be worked wi h a more powerful current, and will therefore speak more distinctly, than any other instrument at present in the field. The construction is sufficiently simple. A number of carbon rods of square section have a circular hole bored through them near one end. They are then strung upon a round carbon rod, which is placed at the back of the diaphragm so that the top ends of the square blocks stand in a row across its central part, where the amplitude of vibration of the diaphragm is greatest. The lower ends of the blocks of square section rest loosely upon a second round rod of carbon. The instrument is therefore merely a multiple microphone, but the construction certainly seems to be well adapted for use with comparatively large currents as claimed.

THE TELEPHONE IN ITALY.—The Commission nominated by the Italian Government to inquire into the question of telephonic communication has addressed the following circular to the Chambers of Commerce, the municipalities, and the proprietors of the telephone lines already in operation:—"The Minister of Commerce has nominated a Commission authorised to inquire into the telephonic service, and the relation of this service to other public departments, and especially to the telegraphs, and also to propose such legislative, administrative, and judicial precautions as may be necessary for the definite regulation of all future concessions for the establishment of telephonic communication. In order to render the work of the commission the more complete, you are requested to be good enough to inform us what are the principal difficulties which have arisen in connection with the telephonic services already established, and what steps you would propose to take in order to safe-guard the interests of the State, municipalities, the general public, and the proprietors of the system."

OZONE BY ELECTROLYSIS.—Prof. H. M'Leod has recently brought before the Chemical Society some results which he has obtained in a series of experiments upon the electrolysis of aqueous solutions of sulphuric acid. These experiments were undertaken in order to determine the quantity of ozone which can be obtained by electrolysis. The positive electrode consisted of a tube containing mercury, with several fine platinum wires of 0·45mm. diameter fused into the glass. The negative electrode consisted of a small plate of platinum. The electrolysis was carried out in a U-tube, surrounded by ice and water; the hydrogen was collected over water, and the ozonised oxygen passed through a tube containing a solution of potassic iodide, by which the ozone was absorbed. The quantity of ozone was determined by acidifying the potassic iodide solution and decolorising by a solution of thio-sulphate. It was found that the maximum quantity of ozone was obtained with solutions about 1·075 or 1·1 in density, the electrolytic oxygen then containing about 16 or 17 per cent. of its weight of ozone.

THE LIGHTNING CONDUCTOR IN ACTION.—The *St. James's Gazette* says:—"On the 27th of July a party of engineers and workmen had an excellent opportunity of observing the way in which a thunder-cloud discharges its electricity. They had just completed the fitting of a lightning conductor at the shelter hut on the Mythen, in Schwyz. A heavy storm was seen approaching from three different points, and they took refuge in the hut. Through a hole in the wall they could see the conductor. From time to time small bluish flames appeared hovering on it; then the lightning flash would be seen descending along the conductor into the earth, followed almost instantaneously by the thunder crash. More than twenty times they watched the phenomena regularly succeeding each other; then there was an electrical discharge of such violence that there seemed to be a recoil, and two of the party felt the shock from below up to their hips, and one fancied that both his legs were shot off. The men were so terrified that they quitted the hut and descended the mountain amid blinding snow, as well as thunder and lightning."

ADVANCEMENT IN ELECTRICITY AND PHOTOGRAPHY.—The following story has been going the round of the Press:—"A wealthy ironmaster in the North of England, whose house and works are dazzlingly illuminated by the electric light, has adopted an ingenious contrivance, by which he may glean some information as to what goes on during his not unfrequent absences from home. In several of his rooms, and in his offices, there is a concealed apparatus in the walls, consisting of a roll of Eastman paper and a train of clockwork. Every hour a shutter is silently opened by the machinery, and an instantaneous photograph is taken of all that is going on in the room. On the great man's return, he delights to develop these pictures, and it is said that they have furnished some very strange information indeed. One clerk, who received his dismissal somewhat unexpectedly, and boldly wanted to know the reason why, was horrified when shown a photograph, in which he was depicted lolling in an easy chair, with his feet upon the office desk, while the clock on the mantelpiece pointed to an hour at which he ought to have been at his busiest. The servants' party in the dining room furnished another thrilling scene!"

ELECTRIC LIGHTING BYE-LAWS IN FRANCE.—The conditions under which an authorisation has recently been granted for the establishment of a central lighting station and the laying of underground conductors in the town of St. Etienne are of a somewhat rigorous character. The articles of the agreement are two in number. The first stipulates the time within which the work is to be completed, and the second simply asserts that the Commissioners may at any time and (practically) for any reason whatever, withdraw the authorisation. They are determined that there shall be no monopoly of supply at St. Etienne. In other parts of the country they are less cautious in this matter; in fact, to sign a contract for the supply of electricity *at a fixed price* for the next *fifty years* is decidedly a rash proceeding on the part of the consumer. Yet this has just been done at Espalion, where (if we may rely upon a recent statement) a local company has undertaken to furnish electricity under the condition of an exclusive monopoly for the above period. The price mentioned is 1,500 francs per annum, for 45 lamps of 10 candles, burning from dusk to dawn all the year round. The effect of a 10 candle-power lamp for street illumination will scarcely be brilliant. In fact, all the figures are so strange than we are disposed to doubt the accuracy of our information.

GLOBULAR "LIGHTNING."—A very detailed account of a discharge of globular lightning comes from Pera. During a violent storm a family seated at dinner saw a "globe of fire the size of a small apple," which entered the open window, sailed slowly across the room, passed between two persons without touching either, and leaving the room by the way which it entered, fell into the street with a tremendous detonation, but without inflicting any injury or damage. Many years ago the writer of this note himself witnessed an almost precisely similar phenomenon, and although only seven years old at the time he has a most vivid recollection of

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the circumstances. A tremendous storm was raging; suddenly, but quite noiselessly, there issued *from the fireplace* a dark red ball, fully 12in. in diameter. It moved slowly and erratically about the room, passing close beside him more than once. The writer well remembers his grandmother taking him by the sleeve and drawing him aside to let it pass. Perhaps the most remarkable thing in this case was that it also retired by the way it had come—that is, *up the chimney.* Shortly afterwards we heard that our neighbour's house had been set on fire by lightning. It seems reasonable to suppose that the appearance may owe its origin to a drop of water in a highly electrified condition. If so, it is scarcely correct to classify the phenomena as lightning; we had better, perhaps, go back to the old word "thunderbolt."

Electrical Train-Lighting on the Glasgow Underground Railway.—The *Scotsman* says: For some time back there has been a good deal of grumbling among the passengers on this line owing to the carriages not being lighted in passing through the tunnels. Several schemes for lighting the carriages by gas and electricity have been submitted to the North British Railway Company, and on Monday the directors and Mr. Walker, general manager, made trial of a carriage fitted with the electric light in the tunnel between Queen-street and College Stations. There was a sixteen candle-power incandescent lamp in each compartment, and by the system tried the lamps light themselves on entering the tunnel, and go out on leaving it. It is proposed to use the electric light in the tunnels during the day time only, and for this purpose the ordinary gas or oil fittings have not been interfered with, so that they can be used at night. We understand the company intend lighting the trains between College and Charing Cross Stations in the meantime, which should be of great benefit to the public, as at present the carriages are dark at some of the stations too. At the trial the lighting was very successful, both when the train was running at full speed and also when standing in the tunnel, while the light was quite as good as gas, and the cost, it is understood, is considerably less. The carriage was fitted up at the Cowlairs Works, and the trial carried out by the railway company themselves. Mr. H. S. P. Carswell, one of the assistant engineers, is the patentee.

A Novel American Installation.—The American confraternity of engineers and electricians are bent on maintaining their reputation for being first in the field when any new line is to be "prospected." For some months past, as we have already taken occasion to mention, the electric lighting station at Lowell, Mass., has been "operated" by an engine deriving its energy from the expansion of bisulphide of carbon vapour. Another American installation possessing points of novelty is now at work at "Cottage City." This consists of a plant which provides both heat and light to the whole town. The lighting is attended to by several of those heterodox machines, the Ball "unipolar" dynamo. It is a decidedly perplexing fact that these machines should continue to find favour in the States, but in this case, as well as in several others of which we have recently heard, their performance is spoken of in terms of satisfaction. However this may be, it is not so much the dynamo machinery which is the strong point of the Cottage City installation. Its distinction lies in the method of utilising the boilers for the double purpose of supplying steam for driving the engines, and also for the manufacture of "water gas" by which the town is provided with all the heat which is required. It is not our intention to go into details as to the methods adopted, although these are of considerable interest on their own account. With a plant of this description the boilers may be profitably employed in continuous working, and it seems not unlikely that under certain conditions the system would find a successful application in this country.

New Cable Proposals.—We take the following extract from the *Sydney Daily Telegraph* for July 3rd:—"The Minister for Education has received a cablegram from Mr. John Pender, chairman of the Eastern Extension Telegraph Company, making proposals on an entirely new basis. They read as follows:—'The proposals for extending the cable subsidy having been declined, the company, as further evidence of their desire to meet the colonies' wishes, and in response to a frequently-expressed opinion that a large reduction of the tariff would result in a large growth of traffic, submit the following proposition for your consideration—namely, the company would be prepared to lower the tariff between Europe and Port Darwin to any figure the colonies might fix down to the limit of out payment on consideration of the colonies guaranteeing the average receipts over the cables for the last three years. If the guarantee extended to the Eastern Company and their partners, the amount the colonies would have to make up at a 5s. tariff—if no increase took place—would be about £107,000; with an increase of 25 per cent., £89,000; 50 per cent., £70,000; 75 per cent., £51,000; 100 per cent., £32,000. At a 4s. tariff without increase, £119,000; with increase 25 per cent., £103,000; 50 per cent., £87,000; 75 per cent., £71,000; 100 per cent., £55,000. The above figures are based on the assumption that South Australia would reduce her transit to 10d. and 5d. per word respectively. This would be a fair way of testing the effects of the cheap tariff, and might be tried as an experiment for five or ten years, at the end of which period, if the results were not considered satisfactory, either party would be at liberty to revert to the existing arrangement. I believe the guarantee principle would prove the best solution for the colonies, as it would give them full control over the tariff and enable them greatly to benefit the telegraphing public.' These proposals are altogether apart from the reductions which came into effect on July 1, and they are now being considered."

An Abstract on Chemical Behaviour of Iron in the Magnetic Field.—E. L. Nichols, in the *Journal* of the Chemical Society, describes a set of experiments with aqua regia, nitric acid, hydrochloric acid, and sulphuric acid, to illustrate the phenomenon that when finely-divided iron is placed in a magnetic field of considerable intensity and exposed to the action of the acid, the chemical reaction differs in several respects from that which occurs under ordinary circumstances. With aqua regia, it was found that the speed of reaction is greater in the magnetic field than without, and that the heat of chemical union is much greater. The production of nitrous fumes under the influence of the magnet, and the yellow colour of the resulting solution, show that the reaction was modified in chemical character. With nitric acid, the effect of the magnet was to greatly increase the speed, reducing the average time from eight minutes to less than one minute. Red fumes always resulted from the action within the field. With hydrochloric acid, the rise of temperature was much smaller than in the experiments with aqua regia and nitric acid; the speed of reaction within the magnetic field differed very little from that occurring under ordinary circumstances; and the character of the reaction in the two cases was almost identical. The rise of temperature under the influence of the magnet, however, was found to be slightly in excess of that produced when the magnet was not in action. With sulphuric acid the reaction was uniform and complete, and apparently of the same chemical character within and without the fluid

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The magnet was found, however, to increase the speed of reaction, and to decrease the amount of heat produced. A series of measurements was made with nitric acid, in which powdered copper was substituted for iron. The reaction in the field was found to be identical with that which occurred when the magnet was not in action. The results arrived at by the author are shown in a series of curves; the ordinates denoting temperature in degrees centigrade, and the abscissæ time in minutes. The experiments are preliminary to a more complete investigation of the novel series of effects developed.

THE UTILISATION OF NATURAL FORCES.—Under this heading the *Bulletin International de L'Electricité* has the following observations, which seem to us to be of a very sensible character :—"If there is any country upon the face of the earth where the forces of nature are most abundantly placed at the disposal of man, surely it is the northern region of the United States. Not only do we here find numberless rivers and streams, but their flow is beneficently regulated by numerous lakes which play the part of so many natural reservoirs. Here, then, above all other places, should we expect to find a field for the employment of electricity in the transmission of power to the centres of industry, and if the schemes of M. Marcel Deprez offered such industrial advantages as are claimed, they should long since have been put into practice in this region. Yet up to the present nothing has been done. The American engineers have preferred to utilise these natural forces upon the spot where they are to be found, and for ourselves we do not believe that they have been wrong in so doing. They are a set of men too well informed, and too expert to neglect an industrial development of this character if it in reality possessed a definite value. The River Blackstone, for instance, passes through the State of Massachusetts, and drives more than 60 mills; the River Merrimac, of which the mean fall is about 0·75m. per kilometre, furnishes motive force to the towns of Laconia, Tilton, Hooksett, Manchester, Lowell, and Lawrence; the rapids in the State of Maine, which fall 1·50m. to 1·75m. per kilometre in some parts of their course, are made to do mechanical work upon their banks; but no one in America has ever dreamt of attempting to transmit their energy to a distance of 50 or 60 kilometres. Can it be otherwise in France? We believe not. We believe that the utilisation of the forces of nature in the particular manner which at present so much engrosses the attention of the daily journals will always remain a scientific possibility rather than an industrial process. The transmission of power by electricity for shorter distances rests altogether upon a different footing, and we believe that this application will before long become of the utmost importance and receive great and continuous development."

GAS V. ELECTRICITY.—Mr. H. G. Massingham has written the following interesting letter to the *Taunton Courier*:—"Dear Sir: In a leading article on the annual meeting of the Taunton Gas Company you say 'Both the general public and the shareholders in the Taunton Gas Company must feel some considerable amount of pleasure in the roseate state of affairs which Dr. Kelly was enabled to present at the recent annual meeting.' As one of the 'general public' it certainly did afford me considerable pleasure to read your congratulatory article. It is now nearly twelve months since I first suggested the desirability of introducing the electric light into Taunton, owing to the numerous complaints of the insufficient lighting of the town, and I at once met the very natural fears of the gas shareholders by stating it would create a demand for more light, and tend to increase rather than decrease the consumption of gas. In addition to which, gas would in the future be more used for cooking, heating, &c., for which it is better adapted than for lighting purposes. I am pleased, therefore, to see that my prediction has been more than realised. I can add my testimony to the great convenience of gas cooking stoves, and also the undoubted economy of using these during the summer months, when fires are not required. I feel the more pleasure in doing this owing to the fact that some of the gentlemen connected with the local gas company cannot forgive me for introducing the electric light into Taunton, but I hope that before long they will realise that while I have tried to benefit the town I have in no way injured their particular interests. Unlike the gas shareholders, I cannot congratulate myself upon any return for my capital, but I have the satisfaction of knowing that I am doing a useful work, and I am pleased to say that were I not giving away the light from the seven parade lamps (which will cease in December) I should be covering all expenses, which is highly satisfactory to me, as I purposely decided to supply the light at the cost of production, directly the local syndicate declined the risk, and I undertook the sole responsibility. Had a local company been formed, as they would have been receiving 10 per cent. more than I am charging, they would have paid a dividend of from 6 to 8 per cent. by the end of the first year."

THE ELECTROLYTIC SEPARATION OF FLUORINE.—The element known as fluorine is chiefly remarkable from the fact that it is the only known element which forms no compound with oxygen. It has an intense affinity for hydrogen, and is extremely difficult to obtain in a separate condition. This difficulty arises in part from the fact that fluorine in the presence of moisture strongly attacks silica; hence it is impossible to treat it in glass or porcelain vessels. The French chemists, Knox and Lonyet, acting upon a suggestion originally due to Sir Humphrey Davy, attempted to prepare this element by treating argentic fluoride with chlorine in a vessel constructed of fluor spar. The experiment did not, however, lead to any very definite results. Since them M. Fremy, by means of the action of dry iodine upon dry silver fluoride, obtained a colourless gas which did not attack glass. Recent researches undertaken by M. Moissau have, however, thrown some slight doubt upon the question whether the gas so obtained is actually free fluorine. M. Moissau having prepared anydrous hydrofluoric acid (HF) by a method due to M. Fremy, submitted it to electrolysis in a platinum U tube under the action of 50 Bunsen elements. Hydrogen was given off at the negative pole, and at the positive pole a gas was obtained which had the following characteristics:—In the presence of mercury it was rapidly absorbed with the formation of proto-fluoride of mercury of a clear yellow colour. In contact with water the latter was decomposed with the formation of ozone. Phosphorous was inflamed with the formation of two fluorides of phosphorous, sulphur was melted with rapidity, carbon seemed to be unaffected, melted potassic chloride cools with disengagement of chlorine; and, lastly, crystallised silicon takes fire and burns with great brilliancy upon contact with the gas, forming silicic fluoride. The platinum iridium electrode forming the positive pole was much corroded, the negative electrode was not attacked. M. Moissau prefers for the present to reserve his opinion as to the exact nature of the gas he has obtained, pointing out that although the most obvious supposition would be that it consists of pure fluorine, yet at present the evidence is not conclusive. It may, for instance, turn out to be a perfluoride of hydrogen, or some mixture of ozone and hydrofluoric acid. It will be noted that the gas differs from that previously taken for fluorine in its action upon silicon.

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ELECTROMAGNETIC INDUCTION AND ITS PROPAGATION.—XXXI.

BY OLIVER HEAVISIDE.

(Continued from page 253.)

The Influence of Electrostatic Capacity.—Impedance Formulæ.

Let us now return to the more general case of section XXIX., the amplitude of the current due to a simple harmonic impressed force at one end of a line. Although the formula (41*b*) for the amplitude at the distant end is very compact, yet the exponential form of the functions does not allow us to readily perceive the nature of the change made by lengthening the line, or making any other alteration that will cause the effect of the electrostatic charge to be no longer negligible, by causing the electromagnetic formula to be sensibly departed from. Let us, therefore, put (41*b*) in the form $V_0/C_0 = \&c.$, and then expand the right member in an infinite series of which the first term shall be the electromagnetic impedance itself, whilst the others depend on the electrostatic capacity as well as on the resistance and inductance.

On expanding the exponentials and the cosine in (41*b*), we obtain a series in which the quantities $P^4 - Q^4$, $P^6 - Q^6$, &c., occur, all divided by $P^2 + Q^2$.

To put these in terms of the resistance, &c., we have, by (37*b*),

$$P^2 + Q^2 = SnI, \quad 2PQ = SnR', \quad Q^2 - P^2 = Sn^2L', \quad . \quad (58b)$$

where

$$I = (R'^2 + L'^2n^2)^{\frac{1}{2}}, \quad . \quad . \quad . \quad . \quad . \quad (59b)$$

I being the short-line impedance per unit length. Using these, we convert (41*b*) to the following form,

$$V_0/C_0 = Il\left[1 - \frac{l^2}{3}Sn^2L' + \frac{2l^4}{45}(Sn)^2(\tfrac{1}{4}R'^2 + L'^2n^2) - \ . \ . \ .\right]^{\frac{1}{2}} \quad (60b)$$

Here we may repeat that V_0 and C_0 are the amplitudes of the impressed force at one end and of the current in the wire at the other end of the double wire of length l, whose "constants" are R', L' and S, the resistance, inductance, and electrostatic capacity per unit length, R' and L' being functions of the frequency already given. I do not give more terms than are above expressed, owing to the complexity of the coefficients of the subsequent powers of S. To go further, it will be desirable to modify the notation, and also to entirely separate the terms depending upon resistance in the [ ] from the others. Let

$$SL' = v^{-2}, \qquad f = (R'/L'n)^2, \qquad h = nl/v. \quad . \quad (61b)$$

Here v is a velocity, f and h numerics. The least value of the velocity is $(SL)^{-\frac{1}{2}}$, at zero frequency, L being the full steady-flow inductance per unit length, as before. As the frequency increases, so does v. Its limiting value is $(SL_0)^{-\frac{1}{2}}$ or $(\mu_2\epsilon_2)^{-\frac{1}{2}}$, the speed of undissipated waves through the dielectric. The ratio f falls from infinity at zero frequency, to zero at infinite frequency. See equations (43*b*) to (46*b*). The ratio h is such that $h/2\pi$ is the ratio of the time a wave travelling at speed v takes to traverse the line, to the wave period.

In terms of I, f, and h, our formula (41*b*), or rather (60*b*), when extended, becomes

$$V_0/C_0 = Il\left[\left(\frac{\sin h}{h}\right)^2 + \frac{fh^4}{90}\left\{1 - \frac{1}{7}h^2 + \frac{1}{105}h^4\left(1 + \frac{1}{12}f\right)\right.\right.$$
$$\left.\left. - \frac{4}{105.99}h^6\left(1 + \frac{3}{16}f\right) + \frac{10}{105.99.91}h^8\left(1 + \frac{3}{10}f + \frac{1}{80}f^2\right) - \ . \ . \ .\right\}\right]^{\frac{1}{2}} \quad . \quad . \quad . \quad (62b)$$

From this, seeing that in the [ ] resistance appears in f only, we see that the corresponding no-resistance formula is simply

$$V_0/C_0 = Il\frac{\sin h}{h} = L_0v\sin\frac{nl}{v}, \quad . \quad . \quad . \quad (63b)$$

where, of course, v is the speed corresponding to L_0, or the speed of undissipated waves. The sine must be reckoned positive always. To check (63*b*) derive it immediately from (41*b*) by taking R = 0. We shall find the following form of (41*b*) in terms of f and h useful later.

$$V_0/C_0 = \tfrac{1}{2}L'v(1+f)^{\frac{1}{4}}\{\epsilon^{2Pl} + \epsilon^{-2Pl} - 2\cos 2Ql\}^{\frac{1}{2}}, \quad . \quad . \quad (64b)$$

where

$$\left.\begin{aligned} Pl &= h(\tfrac{1}{2})^{\frac{1}{2}}\{(1+f)^{\frac{1}{2}} - 1\}^{\frac{1}{2}} \\ Ql &= h(\tfrac{1}{2})^{\frac{1}{2}}\{(1+f)^{\frac{1}{2}} + 1\}^{\frac{1}{2}} \end{aligned}\right\} \quad . \quad . \quad . \quad (65b)$$

Let us now dig something out of the above formulæ. This arithmetical digging is dreadful work, only suited for very robust intellects. I shall therefore be glad to receive any corrections the following may require, if they are of any importance.

It will be as well to commence with the unreal, but easily imaginable case of no resistance. Let the wire and return be of infinite conductivity. We have then merely wave propagation through the dielectric, without any dissipation of energy, at the wave speed $v = (\mu_2\epsilon_2)^{-\frac{1}{2}}$, which is, in air, that of light waves. Any disturbances originating at one end travel unchanged in form; but owing to reflection at the other end, and then again at the first end, and the consequent coexistence of oppositely travelling waves, the result is rather complex in general. Now, if we introduce a simple harmonic impressed force at one end, and adjust its frequency until the wave period is nearly equal to the time taken by a wave to travel to the other end and back again at the speed v, it is clear that the amplitude of the disturbance will be enormously augmented by the to and fro reflections nearly timing with the impressed force. This will explain (63*b*), according to which the distant-end impedance falls to zero when

$$nl/v = \pi, \quad \text{or } 2\pi, \quad \text{or } 3\pi, \quad \&c.;$$

here $2\pi/n$ is the wave period, and $2l/v$ the time of a to-and-fro journey. The current amplitude goes up to infinity.

If, next, we introduce only a very small amount of resistance, we may easily conclude that, although the impedance can never fall to zero, yet, at particular frequencies, it will fall to a minimum, and, at others, go up to a maximum; and that the range between the consecutive maximum and minimum impedance will be very large, if only the resistance be low enough.

Increasing the resistance will tend to reduce the range between the maximum and minimum, but cannot altogether obliterate the fluctuations in the value of the impedance as the frequency continuously increases. In practical cases, starting from frequency zero, and raising it continuously, the impedance, which is simply Rl, the resistance of the line, in the first place, rises to a maximum, then falls to a minimum, then rises to a second maximum greater than the first, and falls to a second minimum greater than the first, and so on, there being a regular increase in the impedance on the whole, if we disregard the fluctuations, whilst the fluctuations themselves get smaller and smaller, so that the real maxima and minima ultimately become false, or only tendencies towards maxima and minima at certain frequencies.

By this to-and-fro reflection, or electrical reverberation or resonance, the amplitude of the received current may be made far greater than the strength of the steady-flow current from the same impressed force, even when the electrical data are not remote from, but coincide with, or resemble, what may occur in practice. To show this, let us work out some results numerically.

As this matter has no particular concern with variations of current density in the conductors, ignore them altogether; or, what comes to the same thing, let the conductors be sheets, so that R' = R, the steady flow value, and $L' = L_0$ very nearly, the dielectric inductance, both per unit length. Then, in (64*b*), let

$$f = 1, \qquad Ql = \pi, \qquad v = 30 \text{ ohms}. \quad . \quad . \quad . \quad (66b)$$

Then, by the second of (65*b*), we find that

$$h = 2{\cdot}85;$$

and, by (64*b*), that

$$V_0/C_0 = \tfrac{1}{2}L_0v.2^{\frac{1}{4}}[\epsilon^{-8284\pi} + \epsilon^{-8284\pi} - 2]^{\frac{1}{2}}$$
$$= 60{\cdot}6L_0 \text{ ohms}. \quad . \quad . \quad . \quad . \quad . \quad . \quad (67b)$$

The ratio of the distant-end impedance to the resistance is therefore

$$\frac{60{\cdot}6 \times 10^9L_0}{Rl} = \frac{60{\cdot}6 \times 10^9}{nl} = \frac{20{\cdot}2}{10h} = \frac{202}{285} \quad . \quad (68b)$$

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by making use of the data (66*b*). That is, the amplitude of the received current is 42 per cent. greater than the steady flow current, when (66*b*) is enforced.

But let $Ql = \frac{1}{4}\pi$, then

$$V_0/C_0 = \tfrac{1}{2} L_0 v . 2^{\frac{1}{2}} [\epsilon^{\cdot 2071\pi} + \epsilon^{-\cdot 2071\pi}]^{\frac{1}{2}}$$
$$= 28 L_0 \text{ ohms};$$

and the ratio of impedance to resistance is

$$\frac{28}{60 \cdot 6} \times \frac{202}{285} \times 4 = \frac{4}{3} \text{ nearly,}$$

or the amplitude of current is only 3/4 of the steady flow current.

And if $Ql = \frac{1}{2}\pi$, we shall find

$$V_0/C_0 = 43 \cdot 5 \text{ ohms,}$$

and that the impedance is slightly greater than the resistance. Whilst, if $Ql = \frac{3}{4}\pi$, we shall have

$$V_0/C_0 = 47 \cdot 8 \text{ ohms,}$$

and find the ratio of impedance to resistance to be $\frac{63}{85}$, making the received current 35 per cent. stronger than the steady flow current.

The above data of $f = 1$, and $Ql = \frac{1}{4}\pi$, $\frac{1}{2}\pi$, $\frac{3}{4}\pi$, and π, have been chosen in order to get near the first maximum and minimum of impedance. The range, it will be seen, is very great. Let us next see how these data resemble practical data in respect to resistance, &c. Remember that 1 ohm per kilom. makes $R = 10^4$ (resistance per cm. of double conductor). Also, that $f = 1$ means $R = nl = 10^5 nl_1$, if l_1 is in kilometres. Then, in the case to which (66*b*) to (68*b*) refer, we shall have, first assuming a given value of R, then varying L_0, and deducing the values of n and l_1, the following results :—

	$L_0 = 1$	$L_0 = 10$,
$R = 10^3$,	$n = 10^3$,	$n = 10^2$,
	$l_1 = 856$,	$l_1 = 8568$.

This is an excessively low resistance, $\frac{1}{10}$ ohm per kilom.; the speeds are rather low, and the lengths great. Next, 1 ohm per kilom.

	$L_0 = 1$,	$L_0 = 10$,	$L_0 = 100$,
$R = 10^4$,	$n = 10^4$,	$n = 10^3$	$n = 10^2$,
	$l_1 = 85$.	$l_1 = 856$.	$l_1 = 8568$.

The $L_0 = 100$ case is extravagant, requiring such a very distant return current (therefore very low electrostatic capacity). Next 10 ohms per kilom.

	$L_0 = 1$,	$L_0 = 10$,	$L_0 = 100$,
$R = 10^5$,	$n = 10^5$,	$n = 10^4$,	$n = 10^3$,
	$l_1 = 8 \cdot 5$,	$l_1 = 85$.	$l_1 = 856$.

Lastly, very high resistance of 100 ohms per kilom.

$$R = 10^6, \quad L_0 = 10, \quad n = 10^5, \quad l_1 = 8 \cdot 5.$$

In all these cases the amplitude of received current is 42 per cent. greater than the steady flow current.

In the next case, $Ql = \frac{1}{4}\pi$, the quantity nl/v has a value one fourth of that assumed in the above; hence, with the same R and L_0, and same frequency, the above values of l_1 require to be quartered. Then, in all cases, the current amplitude will be three-fourths of the steady flow current. Similarly, to meet the $Ql = \frac{1}{2}\pi$ case, use the above figures, with the l_1's halved; and in the $Ql = \frac{3}{4}\pi$ case, with the l_1's multiplied by $\frac{3}{4}$.

A consideration of the above figures will show that there must be, in telephony, a good deal of this reinforcement of current strength sometimes; not merely that the electrostatic influence tends to increase the amplitude all round, from what it would be were only electromagnetic induction concerned, but that there must be special reinforcement of certain tones, and weakening of others. It will be remembered that *good* reproduction of human speech is not a mere question of getting the lower tones transmitted well, but also the upper tones, through a long range; the preservation of the latter is required for good articulation. The ultimate effect of electrostatic retardation, when the line is long enough, is to kill the upper tones, and convert human speech into mere murmuring.

The formula (62*b*) is the most useful if we wish to readily see to what extent the electromagnetic formula is departed from. In this two quantities only are concerned, f and h, or $(R'/L'n)^2$ and nl/v, and if both f and h are small, it is readily seen that the *first* form of (63*b*) applies, the factor by which the electromagnetic impedance is multiplied being $(\sin h)/h$. Even when h is not small the f terms in (63*b*) may be negligible, and the first form of (63*b*) apply. For example, suppose $h = \frac{1}{3}$, and f small, then $(\sin h)/h = 3 \times \cdot 3272 = \cdot 9816$, showing a reduction of 2 per cent. from the electromagnetic impedance.

Now, this $h = \frac{1}{3}$ means $nl_1 = 10^5$, or the high frequency of $10^5/2\pi$ on a line of one kilom., $10^4/2\pi$ on 10 kilom., and so on, down to $10/2\pi$ on 10,000 kilom., always provided the f terms are still negligible. This may easily be the case when the line is short, but will cease to be true as the line is lengthened, owing to the n in f getting smaller and smaller. Thus, in the just used example, if the resistance is 10 ohms per kilom., and $L = 10$, we shall have $f = \frac{1}{100}$ on the line of 1 kilom., and $f = 1$ on 10 kiloms. So far, the f terms are negligible, and the first form of (63*b*) applies. But f becomes 100 on 100 kiloms., which will make an appreciable, though not large, difference; and $f = 10{,}000$ on 1,000 kilom. will make a large difference and cause the first (63*b*) formula to fail. It is remarkable, however, that this formula should have so wide a range of validity.

In the above we have always referred to the distant end impedance. But at the seat of impressed force there is a large increase of current on account of the "charge." Thus, at $x = 0$, by the formula preceding (41*b*) we have

$$\frac{V_0}{C_0} = L'v(1+f)^{\frac{1}{2}} \left[\frac{\epsilon^{2Pl} + \epsilon^{-2Pl} - 2\cos 2Ql}{\cdot\ \cdot\ \cdot\ + \cdot\ \cdot\ \cdot} \right]^{\frac{1}{2}} \quad . \quad (69b).$$

The term impedance is of course strictly applicable at the seat of impressed force. As the speed is raised, this impedance tends to be represented by

$$V_0/C_0 = L'v(1+f)^{\frac{1}{2}},$$

and, ultimately, by

$$V_0/C_0 = L_0 v = 30\, L_0 \text{ ohms.} \quad . \quad . \quad . \quad (70b).$$

if the dielectric be air. L_0 is usually a small number.

(To be continued.)

CORRESPONDENCE.

ELECTRIC BELLS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Could any of your numerous readers kindly inform me about what date electric bells were introduced for house purposes?

In the summer of 1851, while on a visit to a farm house about four miles from this town, I was shown as a curiosity an electric bell in use.

It was also connected with the gate leading to the house to give notice of the approach of visitors.—Yours, &c.,

Dumfries. K.

THE HOTEL SCHWEIZERHOF INSTALLATION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With reference to a notice in the last issue (6th August) of your esteemed journal regarding the electric lighting of the Hotel Schweizerhof, of Lucerne, we beg to inform you that the said hotel is not lighted by 600 Edison lamps, but by a total of 800 Swan lamps.

The central station is situated at Dorenberg, at a distance of about 5 kilometres from Lucerne. There is available at Dorenberg water-power up to 600 horse-power, which is utilised by two turbines for supplying electric light and power to long distances. We have installed there two self-exciting alternate current dynamos, which, running at a speed of 250 revolutions per minute, yield a current of 35 amperes at a tension of 1,800 volts. The primary conductors are four naked copper wires of 6mm. gauge, carried by telegraph poles. The central station is lit by 15 Swan lamps fed by a special small transformer. At 2·4 kilometres from Dorenberg a second transformer will be derived for 1,500 watts to supply current

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to 40 lamps in the "Fluhmuhle," the property of Messrs. Gebruder Troller and Co., who are also the owners of the central station in Dorenberg and contractors for the supply of the electric light to the consumers. The next secondary stations are at a distance of 2·2 kilometres from the "Fluhmuhle," and consequently a total distance of 4·6 kilometres from the central station. Here two first-rate hotels, the Schweizerhof and the Luxernerhof, are lighted by a total of 1,200 Swan lamps, by aid of seven transformers of 7,000 watts each, placed in several parts of the building.

Besides these secondary stations there are several other hotels and public buildings to be provided with electric light from the central station of Dorenberg.

The whole electric plant has been supplied and executed by our firm, being the owners of the Zipernowsky-Déri system for distributing electricity to long distances.—Yours, &c.,

Budapest, 11th August, 1886. GANZ AND CO.

THE LALANDE BATTERY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With reference to your interesting account of the Lalande battery, contained in last week's issue, I notice that in the electrical measurements an omission is made as to the percentage of loss incurred by the use of secondary batteries when used in combination with the primary for electric lighting, and when charged in parallel and discharged in series. The energy derived from six cells is computed to be about 23,000 watt-hours. But a great loss seems to come in if we deduct from the primary E.M.F. the counter E.M.F of the secondary, C E = watts; but from E must be deducted e of the secondary, and we have C $(E - e)$, which reduces the watt-hours very considerably. So that taking the E.M.F. of six cells in series as 4 volts, we have $4 - 2{\cdot}5 = 1{\cdot}5$; then multiplying this by the ampere current we only obtain as available energy something like 9,000 watts, representing more than 8lb. of zinc per horse-power hour. This would, of course, be the measurement in the charging circuit, but in the discharging or lamp circuit we should have 6,000, minus a percentage of loss between the charging and discharging current of, say, 5 per cent. × the E.M.F. of secondary battery; and taking this as 2 volts we have as our final result

$$6{,}000 - 5 \text{ per cent.} = 5{,}700 \times 2 = \frac{11{,}400 \text{ watt-hours}}{746}$$

$$= 15{\cdot}2 \text{ horse-power hours.}$$

—Yours, &c, BATTERY.

REMARKABLE INCANDESCENT LAMP PATENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As every little scrap of information in connection with the above subject is devoured and treasured by the users of incandescent lamps, perhaps it may interest some of your readers to learn a few facts respecting two particular inventions, one of which, to my mind, is very remarkable, claiming, as it does, a historical career, and is well worthy of the study of electrical engineers.

The lamp I allude to is the joint invention of Mr. W. E. Sawyer and Mr. Albon Man [? Mann], who a few years back were residents of New York and Brooklyn, who in the year 1877 became somewhat aroused at the success obtained by Dr. Woodward, of Toroto [? Toronto] (an Englishman by birth), to whom, it may be mentioned, the honor is due for having invented and introduced into Canada the first practical Carbon Glow Lamp, which was exhibited by him in the year 1874 at a grand garden party held at Montreal, as recorded in the Canadian Press at that date.

Messrs. Sawyer and Man [? Mann] then began following in Woodward's footsteps, and studying the question of incandescent lighting, and attempted to improve the Woodward and other lamps then known in America, and with the assistance of an expert agent obtained letters patent for an incandescent lamp having 30 claims; which lamp was afterwards patented in England in the year 1878, and known in this country as Cheeseborough's Patent, which invention since that date (whether legally or not remains to be proved) has undergone considerable changes, both financially and scientifically, which makes its history somewhat remarkable, especially as a correspondent in New York informs me that Cheeseborough, of Liverpool, duly assigned his interest in the patent in 1878 to an American by the name of Jacob Hayes, for the sum of 5s., which is a clear proof it was not considered of much value at the time. Mr. Hayes, after going to the expense of keeping the patents afloat for about six years, got tired of his bargain and resold it, and went through the usual form before Mr. W. H. Broadnax, a United States notary public, in May, 1884, by assigning his interest to one James Yate Johnson, an Anglo-American gentleman well known in the Edison circles, for the large sum of one dollar, thus losing tenpence over the transaction, besides transfer fees and the costs and expenses incurred by him during his ownership of the patent.

Next we find this invention, by some miraculous means, on its way back to England, and is then handled by Messrs. Swan and Stearn, and afterwards transferred by the firm of Swan, Stearn, and Johnson to the Swan Electric Light Company, and by them in due season to the Edison and Swan United Electric Light Company (Limited), the present owners thereof.

It would be a little interesting to learn how many profit and loss accounts have been opened in connection with this invention, also how much money has been expended in chopping and cutting up the original specification of the inventors, whose original claims of thirty in number have dwindled down to three.

Another most remarkable fact in connection with this invention is, it has crossed the Atlantic several times, and has been a frequent visitor in the law courts of England and abroad; and, if reports are true, it may yet have to prove its validity, and the payment of the 5s. paid for the parchment.

It may also be of interest to know that the services of Dr. Woodward have been secured by my firm as an expert witness in our case pending against the Edison and Swan Company.

Dr. Woodward is possessed of a store of information in connection with the art of lamp making, and should there be occasion for him to give evidence on our behalf, we have no doubt that his information will bring out many interesting facts of great importance to those interested in the manufacture of incandescent lamps.—Yours, &c.,

ARTHUR SHIPPEY.

King street, Cheapside, E.C.

[For once we go out of our usual course, and insert a letter which seems at first sight to be written in the interest of the general public; but the concluding paragraphs show that such is not the case. What have we to do with the changes as to ownership of a patent, or how much was paid by each purchaser? Surely the questions, legal and moral, are, Who owns the patent now? and, Is it infringed? The object of the letter, it seems to us, is merely to blind the public to the real point, which is:—A owns a patent, B is supposed to be infringing it, and is proceeded against, when he attempts to excuse his action with the statement that "the patent has been sold and resold for small sums of money."—Ed. *E.*]

THE "REGENT" BATTERY.

In our last issue we published a description of the "Lalande" battery, as applied to the charging of accumulators. We have since had the opportunity of inspecting another primary battery for domestic lighting, which is intended to work directly upon the lamp circuit. Dr. Fleming has recently tested one of these cells, and we publish his report *in extenso* below. The "Regent" battery is the invention of Mr. Maquay. Its E.M.F. upon open circuit is 2·19 volts. It will be seen from Dr. Fleming's report that, considering the fact that the cell belongs to the double fluid type, its internal resistance is remarkably low. A cell measuring 3¼in. by 2½in. by 1½in. has a resistance of only about 0·71 ohm.

This result is attained in part by the construction of the porous pot, which is made of a specially prepared clay containing powdered carbon. The most important feature of the battery is, however, to be found in the manner in which the positive plates are prepared. The details of the process are not yet made public, as the patents have not been completed. It is understood, however, that the inventor has produced an alloy of zinc and some other metal, which he claims to be a true chemical compound. This alloy, upon being amalgamated, enters into such intimate combination with the

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mercury that the external surface of the plate always remains in an amalgamated condition until the whole plate has been dissolved.

It results from this, according to the inventor—and it will be seen that the statement is borne out by Dr. Fleming's report—that little or no local action takes place, notwithstanding that two metals besides the mercury are present in the plate. The constancy of the cell is also very great; in a battery intended to supply eight hours' lighting the E.M.F. falls about 5 per cent. during the first hour after closing the circuit; it then remains perfectly constant during six hours, after which it begins again to fall off. The cost of recharging a battery of 24 cells intended to supply a 16 candle-power lamp at 50 volts is stated to be about 5½d., and including the cost of renewing the zincs after 112 hours' service, this is about equal to gas at 6s. per thousand.

The cell seems to be well adapted for use with a miner's safety lamp. The type supplied for this purpose is of exactly the same weight as an ordinary Davy lamp, and gives from two to three times as much light for a period of 10 hours. The importance of finding a miner's lamp which shall be a real "safety" lamp has been greatly enhanced since (if the report of the survivor at the recent terrible explosion at Leigh is to be relied on) it has been demonstrated that if the gas takes fire inside the Davy lamp the flame may pass through the gauze if any attempt be made to blow it out.

The zinc-alloy plate is immersed in a 5 per cent. solution of sulphuric acid, and the carbon plate stands in a deoxidising solution, the exact composition of which has not yet been made known. It is, however, essentially a bichromate solution.

There can be no doubt that the battery has several very excellent features; of course the weak point is the trouble of changing the solutions and renewing the plates. No doubt the owners of the patents will take steps to minimise this as much as possible.

Dr. Fleming's figures do not, of course, require verification, but it may be of interest to state that some measurements which we had the opportunity of making upon another cell led to entirely concordant results.

It is stated that over 1,200 of these cells are already on order.

Dr. Fleming's report is as follows:—

I have had submitted to me for examination and test a primary battery, called the Regent primary battery, and have carried out experiments upon it at considerable length with the object of ascertaining its character and cost of working. This battery is a two fluid battery, and consists essentially of an outer containing cell, which may be of glass, porcelain, ebonite, or any other suitable material, and an inner cell of porous clay, rendered more highly conductive by a suitable process. The inventor claims to be able to reduce the electrical resistance of the porous septum without at the same time increasing its porosity to liquids, thus limiting the diffusion, whilst reducing the internal resistance. The active or positive element of the battery is an alloy, principally consisting of zinc, so treated that the repeated amalgamation which is so troublesome in ordinary batteries is obviated. The plate remains perfectly bright during consumption, and economy of working by the absence of local action is claimed for it. The other element of the battery is a carbon plate or plates immersed in an oxidising solution. The inventor does not claim special novelty for this oxidising solution, but has arrived by exhaustive experiments at a liquid which combines cheapness with constancy of action, and almost complete freedom from irritating fumes. It is claimed for the battery that, with the greatest simplicity of structure, it surpasses other similarly simple batteries in constancy of electromotive force, and in cheapness of operation. Three samples were submitted to me, a single cell about 5in. by 3¼in. by 1¾in., a smaller cell about 3¼in. by 2½in. by 1½in., and a battery of 24 of these last cells contained in a box about 10½in. by 9½in. by 5in. Calling these two sizes of cells the larger and the smaller respectively, we have the following determinations of the constants of each:—

Large Cell—Internal resistance	=	·26 ohm.
Electromotive force open circuit	=	2·19 volts.
Small Cell—Internal resistance	=	·71 ohm.
Electromotive force on open circuit ...	=	2·18 volts.

The battery of 24 small cells had an electromotive force of 52 volts on open circuit. The large cell was first of all set to generate a current through an external resistance of ·845 ohm., and the value of the current and external activity continually measured. It gave an average current of 1·75 ampere for very nearly five hours, the greatest variation of the current strength during the time being only 2 per cent. on either side of this, and the total drop of strength being about 4½ per cent., that is after five hours the current was 95½ per cent. of the original strength. During this time the cell evolved 8·34 ampere hours of current, and energy developed on the external circuit was 12·38 watt hours. The total consumption of the active plate in the cell was 12 grammes. Hence we may reckon the consumption of the active or positive plate at about 1,000 grammes or 2·2lbs. per 1,000 watt hours. In order to ascertain the amount of waste action a similar cell was allowed to stand unusued for 24 hours, and the loss in weight of the positive plate determined. It amounted to 5·6 per cent. of the original weight. Hence loss by local action is about ¼ p. c. per hour.

Experiments were next made with the small set of 24 cells. It was set up and made to supply current to a 40-volt incandescent lamp. The current and electromotive force at the terminals of the lamp were measured every five minutes for six hours by corrected instruments. During the first two hours there was a drop in electromotive force amounting to about 5 per cent. From the end of the second hour to the end of the sixth hour the current and electromotive force remained *absolutely constant*; the closest inspection did not reveal any change in the reading of the instruments. This is certainly a very remarkable result for cells of this small size. During this time the battery was delivering energy at the rate of 30 watts, and hence in the six hours run delivered 180 watt hours, or about 500,000 foot pounds of energy. During this time the consumption of active plates was about 3 ounces weight in all. At the end of the run the positive plates were as bright and untarnished as when first put in the battery.

The glow lamp used gave during this time an illumination of about 12 candles with remarkable steadiness. The performance of this small battery of 24 cells seemed to me to be worthy of considerable praise. Beginning at 12 o'clock with a current of ·77 ampere, it continued to supply current for two hours at a slightly diminishing rate, falling to ·74 in two hours and then remained nearly constant for four hours more, finally falling ·735 ampere. During this time it did not evolve any perceptible fumes. I have ascertained by independent inquiry what would be the cost of charging these 24 cells, and find that the cost of electrical energy obtained from such a battery would be approximately one penny for 40 watt hours. This means that a 16-candle glow lamp could be maintained in action for about six hours for sixpence, as far as concerns the battery and independent of deterioration of the lamp.

Setting on one side central station lighting, we may say that domestic incandescent electric lighting by means of gas engine and secondary batteries has now arrived at considerable perfection, and can be carried on at a cost very little in excess of gas lighting. Considering all the enormous advantages of incandescent lighting, we may well ask why such method is not in far more general use, and the reply undoubtedly is that people shrink from the first cost of such an installation. Granted that for £10 or £15 a year a small house can be lit by incandescent lamps with gas engine, yet if such installation necessitates £200 or £300 initial outlay the demand will be limited. Now, there is a considerable field of small domestic lighting in which people desire to have a few lamps in their houses, and which could be met and met well by an efficient primary battery. In order, however, that a primary battery may meet the requirements of the case, it must, in my opinion, comply with several conditions:—1. The plates should not require re-amalgamation. This is costly and troublesome. 2. It must have small local action, or small wasteful consumption on open circuit. 3. The electromotive force should not fall off more than five per cent. during the delivery of its normal current in about six or eight hours. 4. There should be no complicated arrangement of pipes and circulation of fluids. These arrangements act well at first, but are excessively liable to get out of order. 5. No mixing of chemicals or strong acids should be required; the exciting solution should be supplied ready mixed and be capable of being put in by any ordinary domestic like oil into a lamp.

Now, these conditions are all of them complied with in the Regent primary battery, and in addition such moderate economy in working, that although the lighting by it will not compete with gas, yet, nevertheless, all things considered, it is not a cost which will inhibit those from using it who desire the luxury of incandescent lighting, and yet do not desire to incur large initial outlay. One thing that very greatly recommends such a primary battery as this for such domestic lighting is that it can be used occasionally or whenever required. Now, no arrangement in which secondary cells are used can be employed intermittently. The secondary batteries rapidly deteriorate under these circumstances. A primary battery can be charged and used one day a week, and then when emptied and cleaned is ready again for use when required.

In addition, I may say that I regard this alloy as used for the positive plates in the Regent battery as a very valuable invention. With a little modification this battery should have large uses in telegraphy and other operations when a constant battery of high electromotive force is required. It can be made small, and there will be useful applications of it in small portable electric lamps. On the whole, I am very well satisfied indeed with the manner in which this battery has comported itself under tests, and am of opinion that under proper management its use should be very extensive, and meet requirements not yet supplied by any existing forms of battery.

We also append the following report from Mr. S. Walker:—

In accordance with your request I beg to report that my further experience of the Regent primary battery has fully borne out the favourable impression I had already formed, as described in my former reports. The particular points in which it appears to me to be superior to other batteries are:—1. The extremely small size and weight within which the inventor has been able to concentrate a given amount of energy. This feature is of paramount importance for miners, and other portable lamps; and I have no hesitation in saying that this invention has rendered a practical portable electrical miner's lamp possible for the first time. 2. Its remarkable constancy. I know of no primary battery for electric light which approaches it in this respect. 3. The special formation of the generating plate, which enables the whole of it to be consumed without attention. 4. The low cost of solution employed. 5. The entire absence of complications. In the matter of cost both of manufacture and maintenance, I consider that the Regent battery compares very favourably with every known battery that can be or is intended to be used for lighting. Its components are the cheapest materials known to commerce for this purpose; and while the cost of the metal consumed in continuous work will be rather less than that of zinc under the same conditions, the cost of the solutions I make out from actual work done under my own eye to be one-sixteenth that given recently by M. Hospitalier as the cost of the best form of battery which had passed through his hands up to that time. I am of opinion, therefore, that the Regent battery may be introduced with every hope of success for lighting either by means of stationary or portable batteries; and that the prices obtainable compared with the prime cost should yield a very handsome margin of profit.

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THE ELECTRICIAN.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 *p.m.*

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CITY AND GUILDS TECHNOLOGICAL EXAMINATIONS.

Although the information contained in the Report of the technological examinations conducted by the City and Guilds of London Institute last May is not so ample or so relevant as one would desire, it is, so far as it goes, encouraging to the promoters of technical instruction, and creditable to the Institute which has been mainly instrumental in establishing that instruction on a sound basis. This is the eighth year of the examinations, and there has been an uninterrupted increase of students from the beginning. Omitting the first two years, a steady growth is recorded year by year of between three and four hundred candidates; and so far from there being any signs of falling away, the present year shows an unprecedented increase of eight hundred. The proportion of successes has varied at times in a rather unaccountable way, being sometimes only half, and sometimes three-fifths or two-thirds of the whole number examined. At the May examinations, five hundred of the additional eight hundred candidates obtained passes, which, to adopt the ambiguous phraseology of the Report, is at least "satisfactory." What is more unmistakably satisfactory is the large increase of centres of examinations during the previous twelve months, showing that the area of the Institute's influence is being rapidly extended. Another gratifying feature is the unusual strength of the Honours list, which numbers 622 for the present year, against 406 at the 1885 examination, notwithstanding the fact that the standard has been gradually raised from year to year. We gather also fro them returns that the number of pupils who come up for second and third examinations has gone on enlarging, affording proof of the serious aims of the candidates, who thus persevere in their studies over a lengthened period.

These, at least, are some of the inferences we draw from the wording of the Report, which is sometimes obscure, and from the figures of the Tables, which are generally confusing. The City Institute's Report has always been brilliant in Tables. Its tabulated statistics are unique specimens of what figures can be made to do duty for in the absence of anything better to talk about. The Director and Secretary appears to revel in columns, much as the Chronicler delighted in genealogies. They are often unintelligible, their object incomprehensible, and their effect not the least edifying; but they look imposing, and have cost the compiler much pains. If they cost the reader less they would be more tolerable. He wants to know something, for example, as to the relative quality of the teaching in evening classes and collegiate institutions. That it is better at the latter than at the former is explicitly stated (but in the baldest terms), and we are referred to Table III., where the comparative failures are worked into elaborate percentages, which are utterly misleading until all the data are examined, and have no particular significance even then. In several cases there are 0·0 percentages of failures in "classes" when there were really no candidates; and 100·0 failures is credited to "other institutions," against 47·3 from classes, when the former only sent two candidates, who failed, whilst the latter sent 114, sixty of whom passed. In Table II. we find at the outset that in the matter of Salt 75·0 per cent. of candidates failed; whereas in Soap it is gratifying that the failures were only 50·0; but our satisfaction is damped when on further inspection we find that soap had attraction for only two British artisans, one of whom did not wash, or, more technically, did not pass. This is how 50·0 failures is arrived at; whilst the 75·0 of the first item turns out to represent three men of salt who failed, out of a grand total of four. When we reflect what a vast difference it would have made to the Secretary's percentage had only one more soap boiler, or even 50·0 of a soap boiler, presented himself for examination, the relevancy of these formidable Tables becomes rather dubious.

On the whole, however, we like the figures of this Report rather better than its English. Applications for examination, we are told, were received "in all the 49 subjects"—just as if 49 were *the* fixed number of subjects. A little further on mention is made of "The new Syllabus in the Raising and Preparation of Ores;" we shall expect next to hear of a new Table *in the* preparation of statistics. Manchester, it seems, heads the list of provincial centres, from which the largest number of candidates have passed, "the number being 169 as against 147"—of all the rest put together one might suppose; but on more careful study we are led to the conjecture that 147 was Manchester's last year's total, "against" which the present year's compares so favourably. The figures of the Report are as eloquently inconclusive as those of the Tables. On page 9 it is argued that there is a substantial increase this year in the number of successful candidates who were examined for the first time. And so there is; but seeing that the total number examined was increased by more than double the increase of any former year since 1881, the inference is not necessarily what the writer intends us to draw. Turning to more trustworthy details, we notice that the interest taken in Electrical Engineering shows no sign of abatement. Under the heading of Telegraphy there is, it is true, a marked falling off of candidates, which is, perhaps, not to be wondered at; but under Electric Lighting the numbers have risen from 105 last year

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to 151; and in Electro-Metallurgy the 25 candidates of last year are this year represented by 36. Of the Central Institution we are only told that during the present summer courses of instruction have been given there for the benefit of teachers; and that the attendance at these courses has been satisfactory. We accept the statement gratefully; but in some subsequent Report it would be more satisfactory to be told precisely what *is* satisfactory, and to whom.

THE INSTALLATION AT TILBURY DOCKS.

From the time of Queen Elizabeth to that of General Gordon Tilbury has been a prominent word in the annals of English history. Schoolboys, by a stretch of the imagination or an incapacity to draw correct inferences from records of glamour and glory, think that Tilbury Fort is a stronger fortification than Gibraltar. It was here that Bishop Cedda baptised our Saxon ancestors. It was here that Queen Elizabeth had a camp to oppose the invasion of the Spanish Armada. It was the weakness of the "blockhouse" that permitted the Dutch, in 1667, to attack our ships in the Thames and Medway. As usual, the "door was afterwards locked," and the old blockhouse converted into a regular fortification.

Future history will probably contain records of Tilbury of a far different character to those which grace its pages in the past. Commercial enterprise has singled out this spot as suited for the construction of gigantic docks, upon which many hundreds of thousands of pounds have been spent, and which are now awaiting business to make the scene one of great activity. It can hardly be said by any stretch of the imagination that the scenery on the Tilbury side of the Thames possesses any beauty. It is in strong and striking contrast to that on the Kentish side of the river. But commerce thinks little of scenery, it looks only to utility, and while steep hills offer no advantages for the formation of docks, the low level muddy Essex shore opposite Gravesend possessed the required advantages. The formation of new docks in a district wherein nothing of the kind was known opened up opportunities for a trial of the electric light such as were unknown in the older works, and the directors did not hesitate to accept the advantages this light offers.

It was last autumn that the directors of the East and West India Docks Company decided to light the whole of the new Tilbury Docks by electricity, and Mr. Crompton (of R. E. Crompton and Co.) was asked to send in a report on the best method of carrying out the lighting. His report was accepted, and after the lapse of several months the contract was entrusted to Messrs. Crompton and Co. The order was given out on 1st January and on 1st July the whole was practically completed and the docks lighted up from end to end. Mr. Crompton's report has been carried out practically without any serious alteration.

The area of land and water to be lighted is very conisderable, exceeding 300 acres, a plan of which will be sufficiently clear from Fig. 1, in which the circles, A A, show the position of the arc lights, and R R show the railway lines. In addition to the outdoor lighting of the quays, jetties, and railway, there are 24 large sheds, each about 300ft. long by sidings, 120ft. wide, which had to be lighted in such a manner that goods could be piled all over the floor of

THE TILBURY DOCKS INSTALLATION.

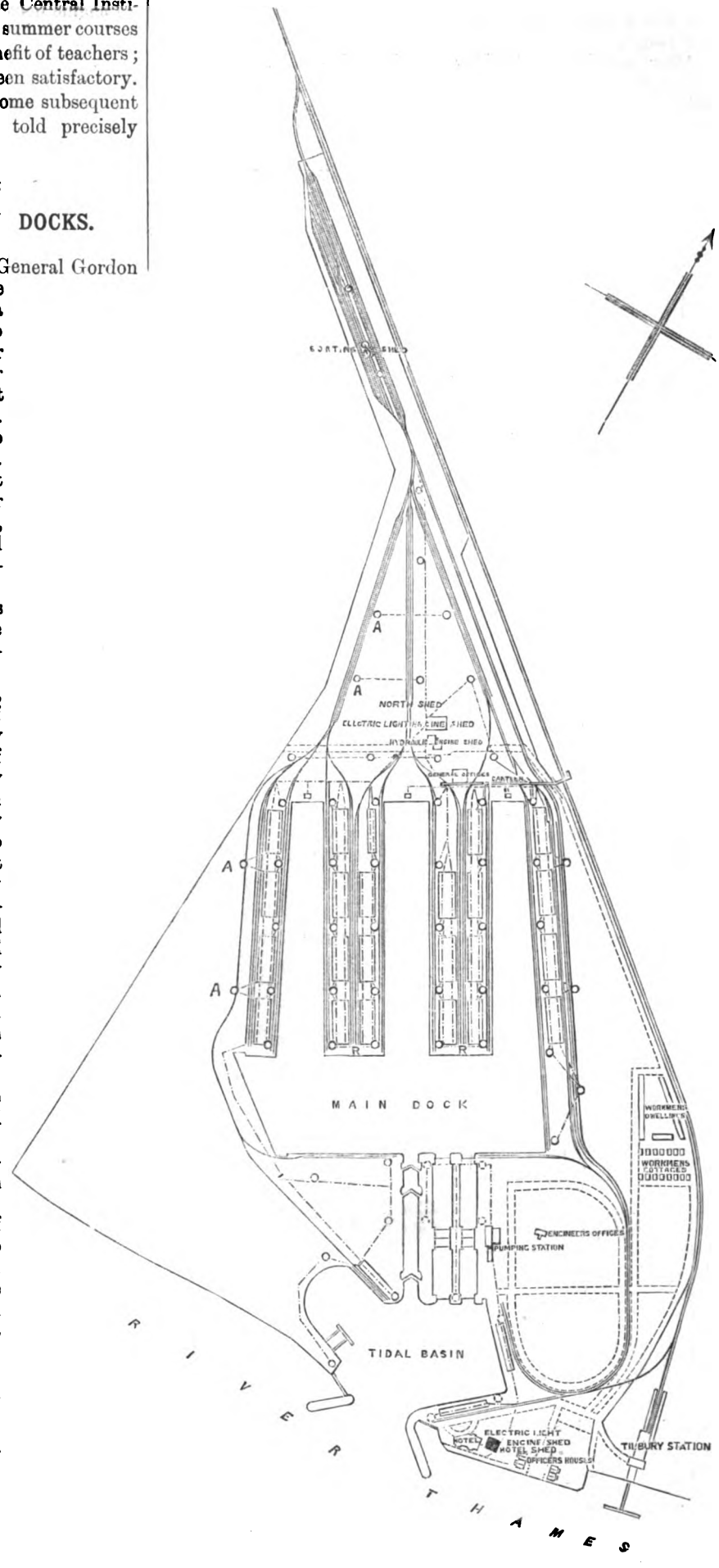

FIG. 1.—Plan of Tilbury Docks.

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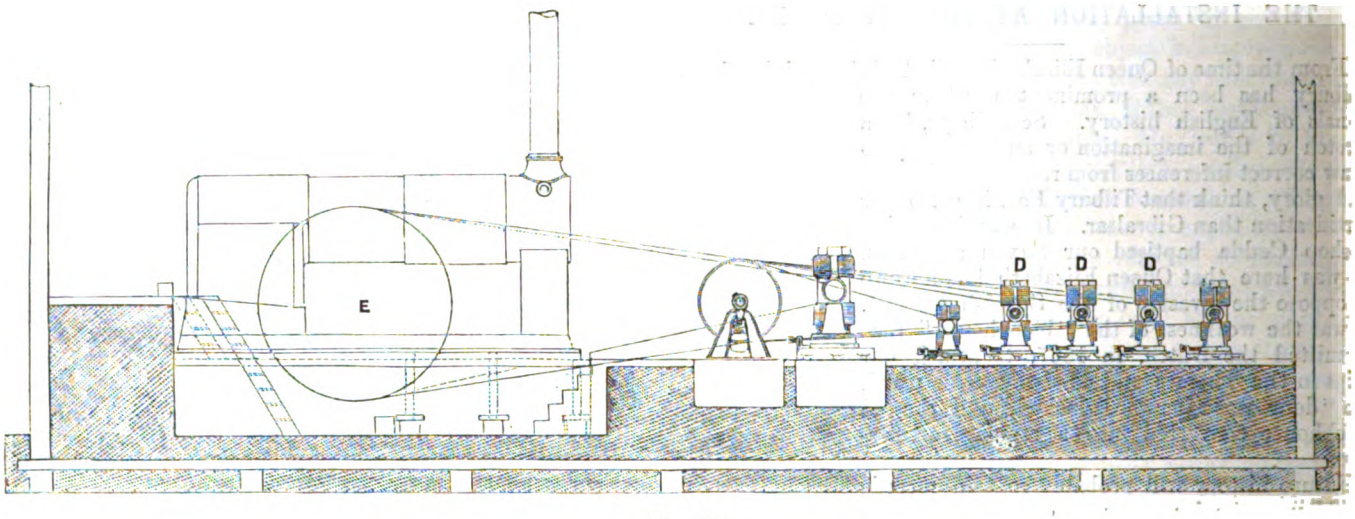
the sheds. In addition to these sheds there was a large number of dock offices and industrial dwellings for the workmen and a large hotel, all requiring to be lighted by incandescent lamps.

After weighing all these considerations Mr. Crompton provided two engine houses, one large one at the north end, containing two engines capable of giving off collectively 360 horse-power, and placed at a point nearly

overhead wires are led along the various lines of sheds to work about 1,000 twenty-five candle-power incandescent lamps, most of which are in the sheds above referred to. From the same engine house current is supplied for working 60 arc lamps, each of about 3,000 candle power, for the quays and railway sidings. A second small engine house is placed close to the hotel, and from it at present eight arc lamps only are worked, but about 400 incandescent lamps are distributed in the hotel

THE TILBURY DOCKS INSTALLATION.



Elevation.

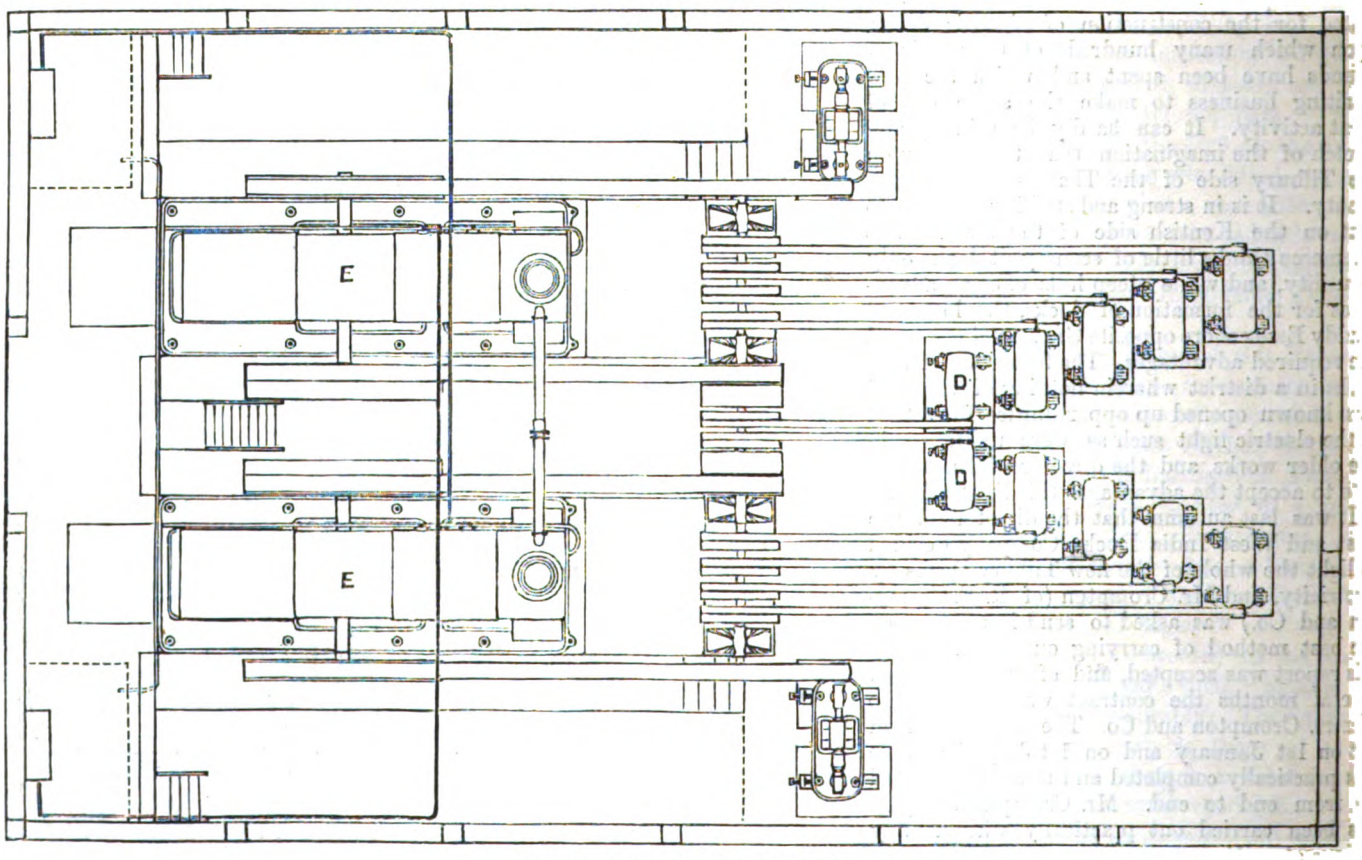


Fig. 2.—Plan. North End Station.

opposite the head of the central jetty and close to the hydraulic engine house containing Sir William Armstrong's hydraulic pumping engines. Fig. 2 is a plan, with elevation, showing the arrangement adopted. EE shows position of engines; DD that of dynamos. This position is fairly central as regards the total length of the area to be lighted, but, unfortunately, is very far from being central as regards the area to be lighted by incandescent lamps. From this engine house

and sheds surrounding the entrance basin. Fig. 3 is from a photograph showing the interior of the dynamo room. Fig. 4 gives a plan and elevation of this room. The northern engine house contains a very fine pair of compound steam engines, having the motion placed underneath the boiler. These engines were built for Messrs. Crompton by Messrs. Fowler and Co., of Leeds. The boilers have steel shells and copper fire boxes, and are capable of col-

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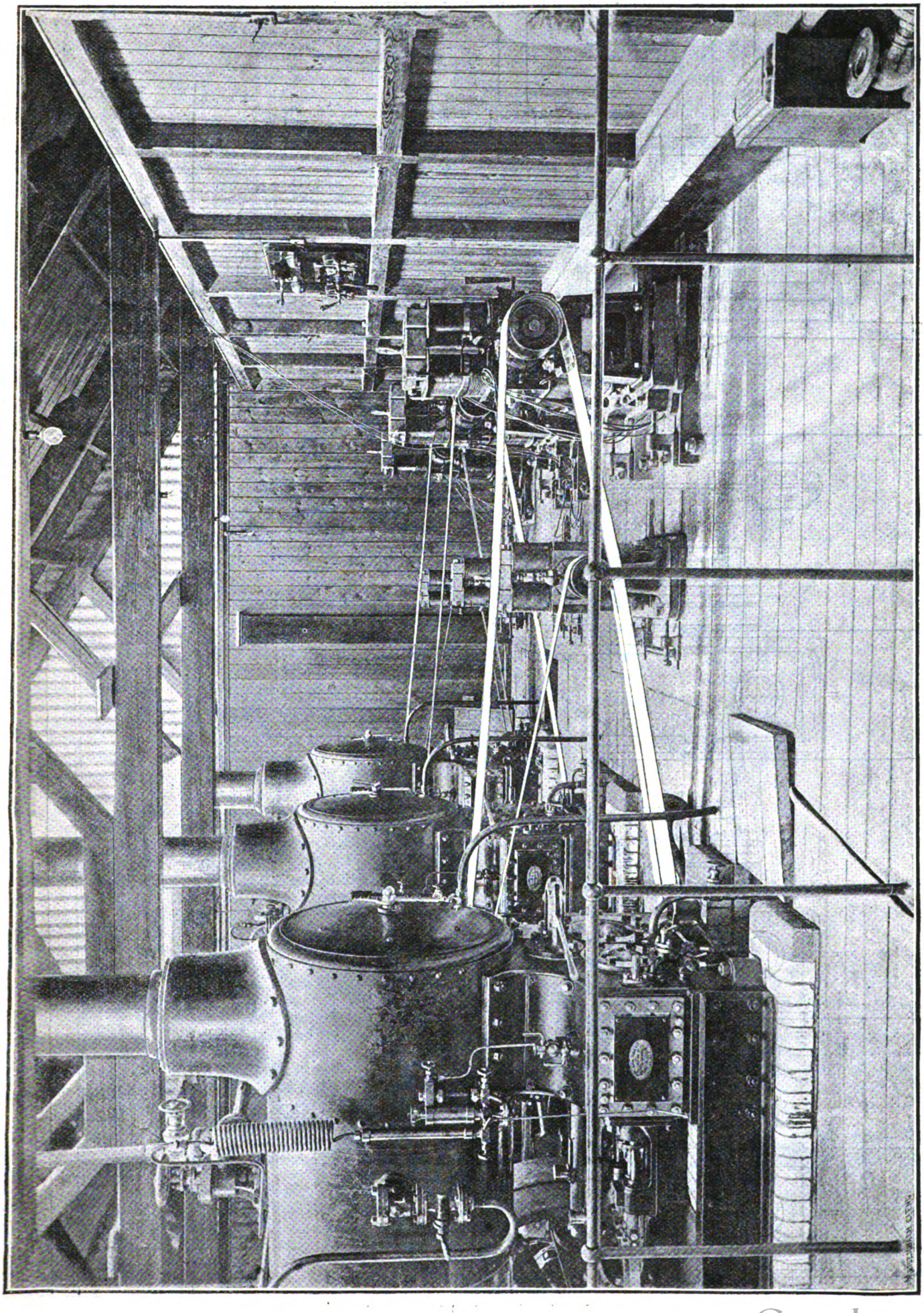

FIG. 3.—Hotel Engine Shed.

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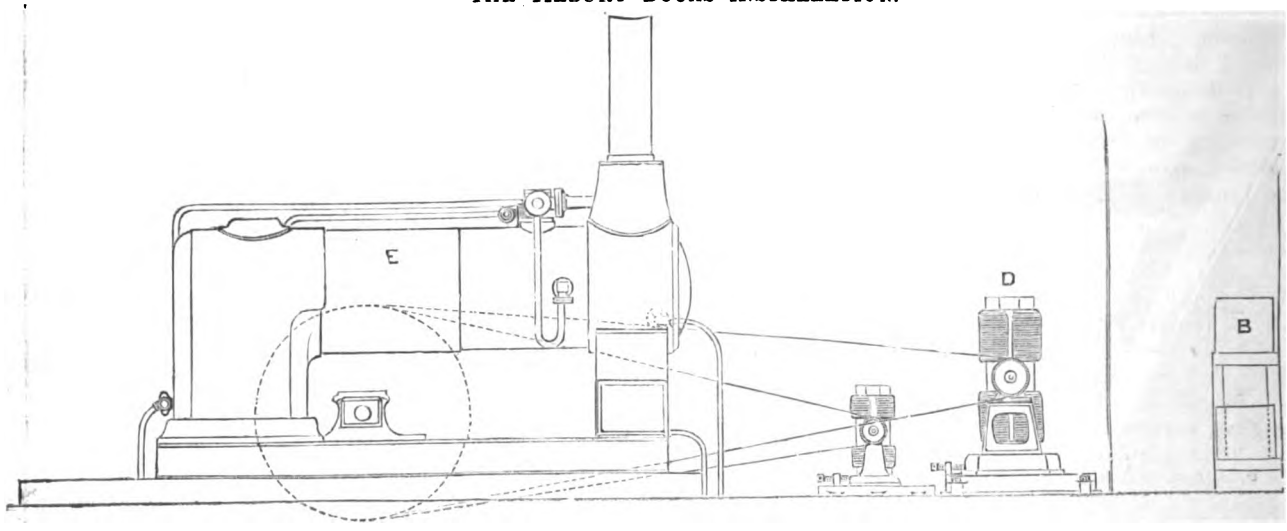
THE TILBURY DOCKS INSTALLATION.



ELEVATION

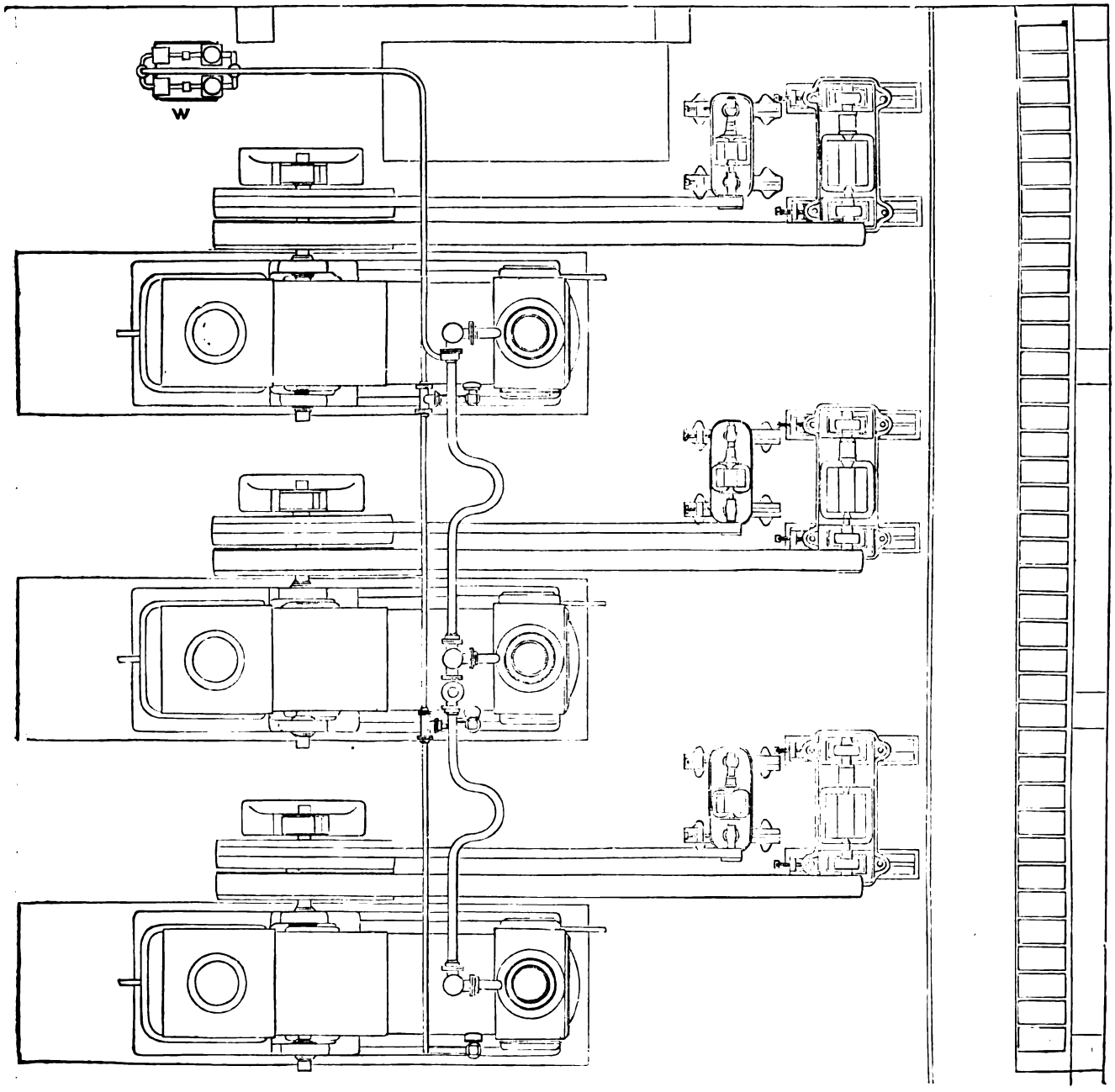


Fig. 4.—Plan. Hotel Engine Shed.

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lectively supplying steam for the engines which during the trial run of one week's duration were regularly worked up to 360 horse-power. Each engine has two large fly-wheels, 10ft. in diameter. One of Messrs. Crompton's L type, or 50 unit dynamos, is driven from the outside fly-wheel of each engine, and a piece of shafting can be driven from the inside fly-wheel of either engine, or from both together, so as virtually to couple the two engines, if it be found necessary. Each of the two large dynamos can give a current of 200 amperes, at an E.M.F of 280 volts at the terminals, or about 56 units, and without any undue heating. The arc light dynamos give a current of from 15 to 20 amperes as may be required, according to weather, &c., at an E.M.F. of 700 volts at the terminals. These arc lighting dynamos are separately excited, and as the exciting current can be varied within certain desired limits, so that any of them can supply from 12 to 14 lamps without varying their speed, the current can also be varied from 13 to 20 amperes, according to the amount of light required. The switching and commutating arrangements are such that any of the arc lighting dynamos can be put on to any circuit, or the dynamos can be exchanged, and any one of the three held in reserve can be put in in the place of one temporarily disabled and with no perceptible stoppage of the light. This is carried out by means of two plug-boards of a somewhat similar pattern to those so well known in telephone exchanges. The commutating arrangement for the incandescent lighting is of a simple character, as there are only two large machines to be dealt with; all the leads from the incandescent lamp distributing circuits of one sign are brought to a common terminal, being protected in the usual manner by fusible safety cut-outs. The other leads are each of them brought to the centre of a switch, the arm of which can be swung round to one or other of two terminal plugs, the terminal plugs being attached to the two machines. The eight arc light dynamos are excited by a pair of small machines, either of which is ample to do the whole work, but the two are introduced to render failure of the exciting current an impossibility; the magnets of the dynamos are in parallel circuit and any one of them can be switched off without affecting the others. These last-named switches are so arranged as to insert three grades of resistances, so as to vary the exciting current to each machine. Dr. Hopkinson, who has throughout acted as inspecting engineer for the dock company, made a series of careful measurements of the electrical output of the various dynamos during the official week of trial. The results show that from 70 to to 72 per cent. of the horse-power of the engine cylinders was obtained as useful commercial output at the terminals of the dynamos. The water supply at Tilbury at present is of very bad quality, and has a tendency to make the boilers prime, so that up to the present time the evaporative efficiency of the boilers has not been so good as was expected; but Messrs. Crompton, however, see their way to remedy this. Taking matters as they are at present the consumption of coal per commercial electrical horse-power rendered at the terminals of the machines has been exceedingly low, not exceeding 3·8lb. As has been said above, the distribution of current to the incandescent arc lamps has been almost entirely by means of overhead wires. This piece of work is interesting on this account alone, as the use of overhead wires has allowed a very large area to be lighted with an exceedingly small cost for copper. A separate pair of wires has been carried from each line of sheds direct to the switch-board at the engine room. The total distance from the engine house of the most distant shed, viz., that called the southern transit shed, is as nearly as possible a mile, and yet the lamps, which require the same E.M.F. as those used in the other sheds, can be turned off in pairs without any noticeable change in the brilliancy of the remainder. Such a large quantity of overhead wiring presents some features of novelty. Commencing from the engine house massive standards framed of pitch pine and supported on large blocks of concrete were found to be necessary to resist the strain of such a large weight of copper. It is found necessary to use these framed standards to carry what may be called the trunk line of wires right across the top of the branch docks. From them the wires are carried through the sheds, their insulators being secured to the iron frame work of the roof of the sheds by wrought iron brackets. The wiring of the interior of the sheds is of the simplest possible description, the whole of the wires being in the roof and in full view, and every circuit can be traced, and, if necessary, repaired, without the removal of any casing. The lamps, which require 130 volts each at their terminals, are arranged two in series; one switch and one cut-out is placed in each branch, so that two lamps are turned out at once. The arc lamps throughout are of Messrs. Crompton's well-known pattern. The outside lights are carried on poles, which are of two patterns; the pattern that is employed along the quay walls calls for no special remark. It consists of an octagon taper pitch pine pole, having a wrought iron arm or davit at the top, to which the lamp is hoisted by means of a wire rope and counter weight. The trimming of the lamp, &c., is carried out on a platform about 14ft. from the ground, so as to be out of the way of the traffic. The other form of pole used is entirely novel, and as it requires rather a lengthened description we must defer this

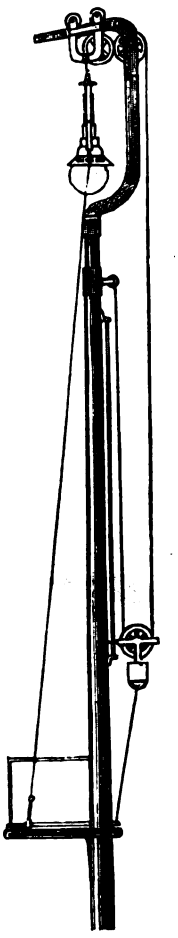

FIG. 5.—Shadowless Pole.

to a future date. Messrs. Crompton, however, have with this pattern succeeded in hoisting the lamp in such a manner that when it is at the top of the pole it is guided into a central position instead of being hung at one side of it as has been heretofore the case. In this case the heavy shadow usually thrown by the pole is avoided, and in place of it there is only a very narrow shadow thrown by the steel arm which carries the lamp itself.

Fig. 5 will enable the reader to understand the peculiarity of this pole. Both classes of poles carry the lamp at about 40ft. from the ground level. In addition to the incandescent lamps inside the sheds, and the arc lights of the quays, a number of portable lights of both classes have been supplied for unloading ships. Portable arc lights can be attached to certain terminal boxes which are provided at regular intervals along the quay walls. Sufficient cable is then payed off a drum hung against the wall of the adjacent shed to enable the lamp to be fixed in a convenient position in the

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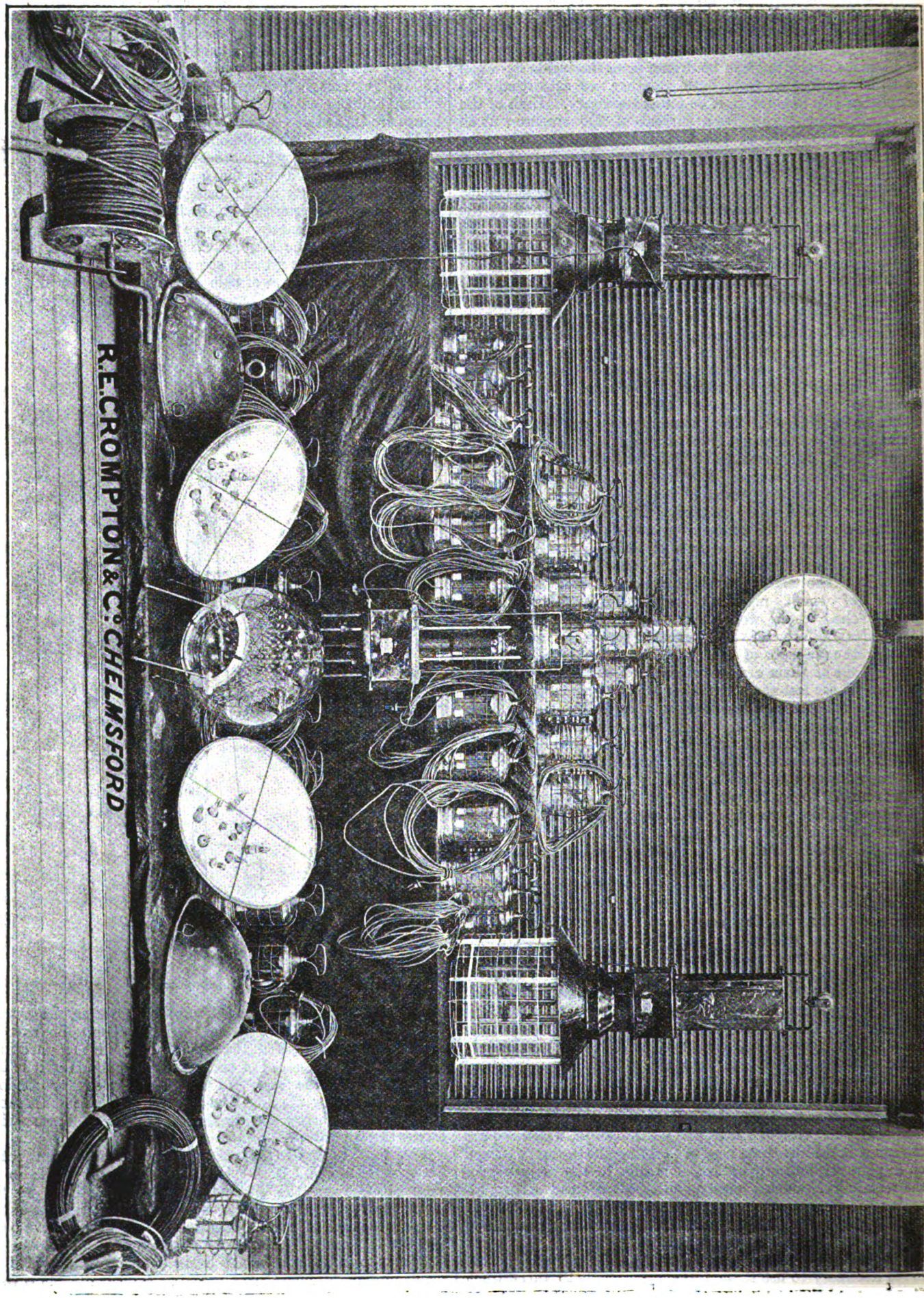

Exhibit of the Various Apparatus Used in the Installation.

THE TILBURY DOCKS INSTALLATION.

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rigging of the ship that is being unloaded. In a similar manner lanterns containing eight 25 candle-power lamps can be lowered anywhere into the hold of the ship in order to supply the light to the more inaccessible parts, and thus assist in unloading the cargo. The terminal boxes for the insertion of these two classes of cargo lights merit special description, but this we must reserve to a future date. The general arrangements from the southern engine house are very similar, but of course on a much smaller scale than those from the northern one. In this latter engine house are not only contained the whole of the lighting for the southern end, including that for the hotel, but also the sewage pumping apparatus for dealing with the sewage from the hotel itself. Owing to the necessity of charging accumulators in order to afford an all-night supply to the hotel, the switch-board arrangements of this southern engine house had to be very special in character, and also merits separate description. The engines in this south engine house were built by Messrs. Marshall, of Gainsboro', and are exceedingly fine specimens of underneath type of compound engines. A great part of the engineering difficulties that have been encountered in carrying out this very large work were due to the difficulty of getting foundations, either for the engine houses or machinery, or for the frame standards carrying the overhead wires. Nearly the whole of the present ground level of the quay, walls, and sheds is made ground, and has been raised from 10ft. to 17ft. above the original marsh level. In nearly every case the foundations had to be carried down to this original marsh level, with the accompanying difficulties of inrush of water and similar troubles. Those who now see the works in a finished state can form no conception of the chaos that existed when Messrs. Crompton commenced operations in January last. The work as now complete offers a good example of modern electric light engineering applied for lighting by a mixed system an area extending to a radius of a mile from the generating station in the cheapest and most economical manner, both as regards capital expenditure and future cost of maintenance.

ON ELECTROLYSIS.*

BY PROF. OLIVER J. LODGE, D.SC.

When in response to an urgent request by the president of Section B I agreed to open the present discussion, it was only after a good deal of hesitation that I consented. For though convinced of the immense importance of a more thorough study of the facts and phenomena connected with the passage of electricity through decomposable bodies, and of its vital interest to all scientific chemists, yet it was not a subject that I had made specially my own, having been, in fact, to a great extent deterred by the immense area it covered, and by the somewhat repulsive character attaching to any borderland branch of science—in this case not wholly physics nor wholly chemistry—a repulsiveness perhaps only subjective, and probably to be attributed to a feeling of incapacity for grasping both aspects of the subject with equal completeness. This difficulty still remains with me, and though I have made a severe attempt to tackle the subject as best I could during the past month, I have been quite unable to cover the immense field, or to read more than the summaries of its literature; and, accordingly, I shall attempt no historical or chronological survey, but shall endeavour simply to direct attention to certain theoretical points which are undoubtedly of interest and importance, and to suggest the answers which I myself feel inclined to give to debatable questions which bristle round even the most elementary facts, in the hope that attention being thus directed to them, success in finally solving some of them may be attained by a more competent hand.

Naturally I confine myself to the more physical aspect of the subject, because, my chemical knowledge being of a meagre and antiquated description, it is better worth your while that I should attempt reasonably good physics than that I should perpetrate unreasonably bad chemistry. Moreover, no chemical development will be satisfactory and permanent unless erected on a thorough physical basis; and if I may venture an opinion on such a subject, I believe that the work of a few chemical philosophers spent in broadening and deepening the foundations of their science would soon confer upon the superstructure a less unsightly and lopsided appearance than, seen from outside, it at present has

The first question which presents itself is—I. What is an electrolyte? The question may have either of two distinct meanings—*(a.)* Is a substance an electrolyte at all; *i.e.*, when alone? *(b.)* Is it the electrolyte in any particular case; *i.e.*, when mixed with other substances?

First meaning of I.—As answers to *(a)* certain chemical statements have been made, such as "all electrolytes are compounds of a metal with a non-metal" (Miller); "electrolytes are either simple binary compounds, or are capable of being formed from them by double decomposition, the *ions* being the radicles so exchanged" (Wiedemann), &c. Such statements may be true, and if true may be important chemical generalisations, but they are not physical definitions or tests of electrolytic conductivity.

As a physical definition of an electrolyte, we have only to say *an electrolyte is a substanee which conducts electrolytically.* A statement like this only helps by fixing our attention on the real point in question, viz., the difference between electrolytic and metallic conduction—a true physical distinction, which is capable of definite examination, and may be capable of precise statement. Whether we are able thus sharply to divide off electrolytes from other conductors will depend on whether any substance be found which can conduct both like a metal and like an electrolyte. Such a substance is not yet, I believe, certainly known, though it has been often suspected; it has even been suspected that all electrolytes have a trace of metallic conductivity. Though for the present this is quite unproved, and may be regarded as against the weight of evidence, it would be rash to insert the word *wholly* into the above definition; it must be left as meaning that *in so far* as a body conducts electrolytically, so far it is an electrolyte.

Now, electrolytic conduction differs from metallic conduction in several ways. Metallic conduction appears to be a true passage of electricity through matter; it is unaccompanied by any reversible or chemical process, it simply generates heat. Electrolytic conduction is accompanied by certain reversible chemical processes, and appears to be of the nature of a convection of electricity by the atoms of matter. A substance which so conducts is an electrolyte, and whether it be a good or a bad conductor is foreign to the inquiry.

It is important to notice this, because it is often sought to deny that (say) water is an electrolyte by showing that it is a bad conductor. Of course, if it *does not conduct at all* it is no electrolyte but a dielectric. Our definition says, first, that an electrolyte must conduct, and it then proceeds to say how it must conduct. Water, alcohol, turpentine, glass, either conduct a little or they do not. If they do not they are dielectrics pure and simple; but experiments on leaks have always shown a more rapid leak if water, alcohol, or turpentine be used to replace air, and as to some kinds of glass it seems to be a mere question of temperature whether they conduct or not. If it be proved that any of these things, even when pure, conduct, be it ever so badly, they are not simple dielectrics, and it remains only to consider whether their conduction is metallic or electrolytic. But it may happen that some of these bodies, or *perhaps* all liquids, behave as dielectrics to rapidly intermittent or alternating E.M.F.'s, but as electrolytes to slow and long-continued E.M.F.'s, just as pitch is elastic to rapid vibrations (it can transmit sound for instance), but is viscous and essentially fluid to long-continued forces. Whether this is so or not is a vital question in relation to the electromagnetic theory of light, wherein the transparency of conducting liquids has only been provisionally and tentatively explained.

Tests for Electrolytic Conduction as distinct from Metallic —So far as experiment has yet gone, electrolytic conduction is found to obey Ohm's law—a remarkable and important fact, if fact it accurately be—and we will return to it later. The obedience to Ohm's law shown by electrolytes prevents our drawing any easy and sharp line of demarcation between the two classes of bodies. To distinguish between them we have to study what happens at a boundary or junction of the two classes of conductors

At such a place Ohm's law utterly breaks down; a finite E.M.F. is needed to drive any permanent current, however small, and the reason is that the atoms which have conveyed the electricity through the electrolyte can accompany it no longer, and have either to give it up and let it go on without them, or cling to it and stop the current. In either case we have what is called polarisation. If the clinging power of the atoms is greater than the applied E.M.F. the current may wholly cease, and as soon as the E.M.F. is removed will spring back again, the opposition to it being no longer like friction, but like a strained spring. If the applied E.M.F. overcome the atomic force the current flows on leaving the discarded atoms to do what they like. They may combine with each other and separate from the liquid, in which case we have visible chemical decomposition; or they may combine with each other and dissolve in the liquid; or they may combine with the liquid, forming secondary products; or they may combine with the electrodes.

They usually cling tightly to the electrode, even if unable actually to combine with it, and by thus altering its surface they may give rise to a permanent opposite current. The four possibilities are—Combination with, or solution in, the liquid; combination with, or deposition upon, electrodes; combination with something already dissolved in liquid; combination with each other and freedom.

Wherever visible decomposition occurs there is no doubt of electrolysis, so that is the most simple and obvious test of electrolytic conduction. But the conductivity may be so bad that no visible product forms in a century. In that case *polarisation*, if present, is a test. As Helmholtz says: "Galvanometers are sensitive enough to show a current which could only decompose a milligramme of water in a century."* But this test also may fail by reason of secondary actions. It is the merest commonplace that an ordinary voltameter behaves as a very leaky condenser. A continual drain of electricity goes through it, however small the E.M.F. applied; and when charged and left, the charge is found very rapidly to diminish. It is facts like these, of course, which have so often suggested slight metallic conductivity, and which at one time tempted Faraday to postulate this.

With certain fused salts the decay of polarisation is so rapid that polarisation hardly appears to exist; and quite a strong current can be sent through them without any visible decomposition. Clark † has shown that in these cases it is the solution of the liberated ions and their rapid

* From the Report of the British Association.

* One may notice that even such a current as this is still 10 electrostatic units per second.

† J. W. Clark, *Phil. Mag.*, October, 1885.

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diffusion which causes this apparent metallic conduction. There is probably a full quota of decomposition, but unless special precautions are taken re-composition is just as rapid. The same thing goes on far more slowly in dilute acid, especially if it contain dissolved gases; and the experiments of Helmholtz with an ingeniously-contrived gas-free cell, as related in his Faraday lecture of 1881, may be taken as settling the quantitative question whether this decay of polarisation is any of it due to slight metallic conduction, and whether the whole of it is rigorously due to solution and diffusion of the semi-liberated ions. It is, of course, true that these experiments do not settle it for all electrolytes, but for dilute sulphuric acid, at any rate, they prove that the diffusion and indirect re-combination of the ions accurately account for everything, and that when these are stopped a voltameter behaves as a good and non-leaking condenser up to a certain E.M.F., beyond which it conducts with visible decomposition. It may be as well, perhaps, to avoid misconception by stating that by the solution and re-combination spoken of above, I do not absurdly suppose that nascent O and nascent H, respectively dissolved in the liquid, travel to meet each other and combine. Upon such direct action as that the presence or absence of dissolved air could have no influence. What one supposes to go on is this. Semi-liberated hydrogen, finding dissolved oxygen in its neighbourhood, combines with it; the corresponding oxygen simultaneously liberated at the other pole dissolves in the liquid, and, so replenishing it, keeps the action continuous at a slow rate regulated by the rapidity of diffusion.

I see nothing, however, to prevent a liberated ion from dissolving in the liquid or from diffusing across to the other electrode, where it may combine with the nascent ion, and so reduce the apparent output of the cell; and this action, having nothing to do with dissolved air, might go on even in Helmholtz's gas-free cell. But it could not begin, I imagine, unless the E.M.F. were sufficient to set both ions free;* consequently, by never applying more than a feeble E.M.F., this disturbing action may be obviated. When dissolved oxygen already exists, neither ion has really to be set free; consequently, even a feeble E.M.F. is sufficient to maintain a weak current.

In cases where the polarisation test for electrolysis thus fails, Helmholtz proposes another—viz., Electrolytes do not fall into Volta's tension series. An assemblage of metals at constant temperature can give no permanent current; introduce an electrolyte into the series, and they can.

On this principle Helmholtz considers he has proved that the conduction of glass is not metallic; for he makes a Daniell cell with a complete glass partition in place of a porous cell, and finds that the glass does not stop the current by polarisation, as a metal partition would, but that the cell behaves exactly like any other cell with an enormous internal resistance. One more test those of us who believe in the electrical theory of light may suggest—viz., transparency. A conductor, if transparent, must be an electrolytic conductor. Thus, a fused salt, if it be clear and transparent, and yet conduct well—as argentic iodide does for instance—may be assumed to be an electrolyte, despite the absence of products of decomposition and of polarisation, unless, of course, rigorous proof can be given that its conduction is metallic, which has in no case happened yet. Electrolytes seem necessarily fluid, and it is difficult to imagine the locomotion of atoms which accompanies electrolysis to go on in a solid body. Mr. Shelford Bidwell, Dr. Silvanus Thompson, and others, consider they have found solid electrolytes, but it behoves us to be very careful in accepting such an idea. Extreme viscosity there may be, as in hot glass, but not the true rigidity of a solid, unless certain proof is forthcoming.

(*To be continued.*)

THE HEATING OF AERIAL CONDUCTORS BY ELECTRIC CURRENTS.†

BY J. GILBERT WHITE, PH.D.

(*Continued from page 287.*)

The next set of experiments had for its object the determination of the law of the relations of different currents, and the temperatures which they were able to maintain.

TABLE VII.

R. for bare wire.	R.	R'. for bare + insulated wire.	R'.	Thompson Ammeter. Right.	Thompson Ammeter. Left.
4,020	4,020	8,006	8,007	0 0	0·0
4,195	4,198	8,338	8,343	38·8	41·0
4,195	4,193	8,345	8,343	41·0	41·8
4,195	4,195	8,338	8,340	40·0	39·3
4,193	4,190	8,330	8,330	38·0	38·6
4,193	4,195	8,333	8,335	38·8	38·6
Mean of R. 4,194		Mean of R'. 8,338.		39 63	

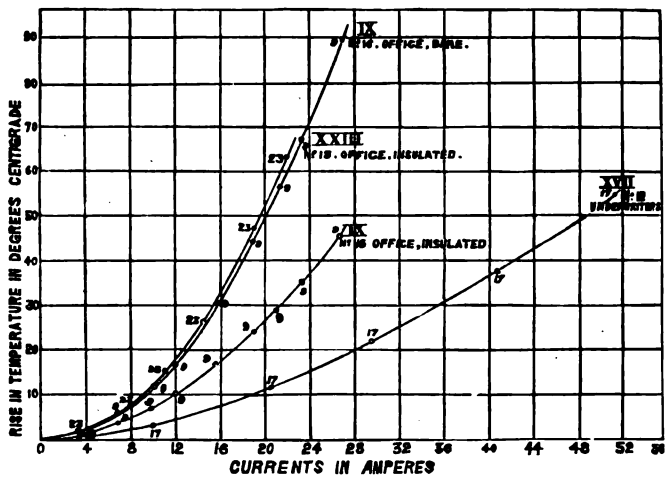
* The E.M.F. required to set an ion free enough to enter into solution is almost enough to set it free altogether. The only difference, I suppose, is pdv; and at ordinary pressures this is negligible.

† From the *Electrician and Electrical Engineer* (New York).

After the current is started in a wire, the emission of heat will increase with the temperature of the wire, until the heat given off just equals the heat developed, when the temperature of the conductor will remain constant. But each current will have its own permanent temperature for any wire under given conditions. To determine the law of this variation, a current was started and allowed to run fifteen or twenty minutes before any observations were taken. Then observations were taken as in the above sample set, the readings of each horizontal line being taken before any of those in the next lower line.

In the following tables all the experimental data were found by taking the average of a number of determinations similar to the above, and the calculations were made from these averages.

Plate II.



The curves on the cross-section paper, Plate II., were laid out by taking the rise in temperature of the wire in degrees centigrade as ordinates, and the currents in amperes as abscissæ.

Experiments 1, 2, 3, 4, 5, 6, were made with No. 16 wire, all of the same piece, the bare part having been stripped of its insulation, which was a double layer of paraffined cotton. Nos. 1, 2, 3 and 4 were conducted with the two parts of the wire suspended side by side in a closed room, about 50 feet of each kind being used.

In 5, 6, 7 and 8 the wires were arranged in a similar manner in the open air, the remainder of the apparatus being inside the laboratory.

TABLE VIII.—Experiment 1.—Set 2.

Resistance of bare wire.	Resistance of both.	Resistance of insul.	% of increase, resist. of bare.	Rise in temp. of bare.	% of increase, resist. of ins.	Rise in temp. of ins.	Current in amperes.
4,019	7,980	3,961	0 0	0·0	0·0	0·0	—
4,194	8,337	4,143	4·35	11·5	4·62	12·2	4·62
4,279	8,470	4,190	6·48	17·0	5·72	15·0	8·30
4,295	8,477	4,181	6·56	17·5	5·64	14·6	8·67
4,442	8,695	4,257	10·42	27·4	7·47	19·6	12·17
4,593	8,938	4,340	14·40	37·8	9·57	25·2	16·63
4,754	9,203	4,448	18·31	48·2	12·26	32·3	18 58
5,075	9,668	4,593	26·02	68 4	15·94	41·9	22·00
5,013	9,582	4,569	24·73	65·1	15·09	39·7	22·10
5,282	9,972	4,690	31·42	82·7	18·14	47·1	25·19
5,624	10,545	4,898	40·50	106·6	23·15	60·9	29·29

The observations of the above table were not all taken the same day, so there is some irregularity, owing in part, at least, to changing atmospheric conditions.

TABLE IX.—Experiment 2.—Set 2.

Resistance of bare wire.	Resistance of both.	Resistance of insul.	% increase, resist. bare.	Increase in temp. of bare.	% increase, resist. of ins.	Increase in temp. insul.	Current in amperes.
4,240	8,405	4,165	—	—	—	—	—
4,263	8,445	4,182	0 54	1·4	0·41	1·1	3·29
4,330	8,539	4,209	2·12	5·4	1·05	2·9	6·66
4,429	8,691	4,262	4·46	11·4	2·09	5·3	10·03
4,685	9,080	4,395	10·73	27·5	5·52	14·2	15·85
4,966	9,508	4,542	17·01	43·6	9·05	23·2	19·73
5,330	10,022	4,692	25·71	65·9	12·65	32·4	23·25
5,737	10,643	4,906	35·30	90·5	17·55	45·5	28·09

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TABLE X.—Experiment 3.—Set 2.

Resistance bare.	Resistance both	Resistance insul.	% increase, resist. bare.	Increase in temp. of bare	% increase, resist. insul.	Inc. in temp. insul.	Current in amperes.
4,210	...	4,142	...	...	...	...	...
4,227	8,382	4,155	0·41	1·1	0·38	1·0	3·62
4,301	8,492	4,191	2·16	5·7	1·18	3·0	7·04
4,389	8,634	4,245	4·23	11·1	2·48	6·5	9·73
4,534	8,857	4,323	7·69	19 7	4·13	10·6	13·38
4,725	9,121	4,396	12 23	31 3	6·13	15·7	17 03

TABLE XI.—Experiment 4.—Set 2.

4,180	...	4,172	...	...	...	...	...
4 201	8,390	4,189	0·53	1 4	0 41	1·1	3 22
4,309	8 546	4,237	2·14	5·5	1·15	2·9	6·64
4,390	8 666	4,276	4·52	11·6	2·48	6·5	9·63
4,500	8 864	4,354	7·64	18·3	4·26	10·9	11·84
4,717	9,144	4,427	12 07	30·9	6·01	15·3	15·65
4,946	9,512	4,566	17 52	44·9	9·42	24 5	19·00
5,127	9,778	4,649	21·95	56·3	11·40	28·5	21·00
5,328	10,083	4,760	26·86	67 2	14·04	35·1	23·48
5,787	10,719	4,932	35·40	89·0	18·18	45·5	26·c8

TABLE XII.—Experiment 5.—Set 2.

3,833	7,750	3,917	...	...	...	...	...
3,846	7,783	3,937	0 51	1·3	0·34	0 9	4·01
3,890	7,900	4,010	2·37	6·1	1·53	3·9	12·36
3,973	8,167	4,194	7·72	19 8	3 66	9·4	17·18
4,260	8,776	4,507	15·06	38·6	8·57	22·0	27 62

TABLE XIII.—Experiment 6.—Set 2.

3 880	7,683	3,803	...	...	...	...	...
3,901	7,736	3,835	0·54	1·4	0·88	2·3	3 31
3,949	7,831	3,882	1·77	4·3	2·07	5·3	6·80
4,011	7,928	3,917	3·37	8·6	3·00	7·7	11·64
4,029	7,963	3,934	3·84	9·8	3 45	8·8	14·90
4,207	8,276	4,069	8·42	21·6	6·00	15·4	19·50
5,907	10,952	5,025	53 26	136·6	32·15	82·4	40·83

TABLE XIV.—Experiment 7.—Set 2.

3,940	8,020	3,980	...	...	...	...	...
4, 222	8,285	4,0c3	7·15	18·3	2·09	5·3	16·07
4,397	8,600	4,203	11·34	29·1	5·60	14·3	21·81
4,655	9,026	4,371	17 88	45·8	9·82	25·1	26·90
5,122	9,730	4,608	30·00	76·9	15·78	40·5	33·97

TABLE XV.—Experiment 8.—Set 2.

3,950	7,890	3,940	...	...	...	...	...
4,032	8,020	3,988	2·08	5·3	1·22	3·13	7·96
4,118	8,174	4,056	4·25	10·9	2·94	7·5	13·68
4,265	8,376	4,111	7·97	20·4	4 34	11·1	21·05
4,755	8,560	4,205	10·25	26·3	6·73	17·0	26·93
4,902	9,350	4,448	24·40	62 6	12·89	33·1	34 52

[Note.—Experiment 5 of the above set was made during a driving snowstorm, hence the increase in temperature for a given current is less than in any other experiment.]

The following experiments in this set (Nos. 9, 10, 11, and 12] were made with a piece of No. 12 "underwriter's wire" alone for x.

TABLE XVI.—Experiment 9.—Set 2.

Resist. R.	% increase resist. x.	Rise in temp.	Current in amperes.
2,174	0 0	...	...
2,187	0 60	1·5	8·15
2,214	1·84	4·7	16·17
2,264	4·14	10·6	24·16
2 330	7 13	18·3	35·13
2,398	10 30	26·4	38 93
2,560	17·76	45 5	51·95

TABLE XVII.—Exp. 10.—Set 2.

2,152	...	...	...
2,180	1 30	3·3	10 09
2, 248	4 56	11·7	20·78
2,332	8·46	21·9	29·33
2,475	15 72	37·7	40·77
2,610	21·40	54 9	51·62

TABLE XVIII.—Exp. 11.—Set 2.

2, 146	...	...	...
2,164	0·84	2 2	8·22
2,214	3·16	8·1	18·41
2, 307	7·48	19·2	27·22
2,461	14·65	37 5	39 89
2,683	24·79	63·5	52·69

TABLE XIX.—Exp. 12.—Set 2.

2,150	..	...	...
2,181	1·44	3·7	12·55
2,555	18·84	48·3	46·47
2,726	26·79	68·7	54·91

TABLE XX.—Exp. 13.—Set 2.

Resist. R.	% increase resist. x.	Rise in temp.	Current in amperes.
6,113	...	...	...
6,165	0·85	2·2	3·14
6,405	4·76	12·2	9·43
7,265	18 85	48·3	19·50

TABLE XXI.—Exp. 14.—Set 2.

6,150	...	...	...
6,192	0 68	1·7	3·24
6,271	1 95	5·0	6·52
6,468	5·17	13·3	10·58
6,650	8·11	20·8	13·68
6,942	12·88	33·0	16·83
7,443	21·02	53·9	21 10

TABLE XXII.—Exp. 15.—Set 2.

6,075	0·0	0·0	0·0
6,236	2·72	7·0	7 47
6,764	11·22	28·8	15·19
7,439	23·59	60·5	21·37
6,115	0·0	0·0	0·0

TABLE XXIII.—Exp. 16.—Set 2.

6,100	...	...	...
6,138	0 63	1·6	3·26
6,281	2·96	7·6	7·76
6,502	6·59	16·6	11·27
6,721	10·34	26·5	14·14
7.205	18·11	46·4	19·29
7,602	24·62	63·1	22·10

In the preceding set of experiments, Nos. 13, 14, 15, and 16 were made with No. 18 paraffined office wire, cotton wrapped.

The next set of experiments had for its object the determination of the relation of the diameter of a wire to the temperature at which a current could maintain it. To accomplish this with accuracy it is essential that the changing atmospheric conditions should not introduce a variable factor into the results. To avoid this one wire was taken as a standard, with which all the others were compared. By arranging the two wires as previously described they could be compared under exactly similar surroundings; and the standard wire in each set of experiments would show any change in atmospheric conditions and permit of corrections being made.

The diameters of the wires were determined by measuring with a micrometer screw gauge reading to ten thousandths of an inch. Each diameter was measured ten times in different parts of the wire, and the average of these ten readings is the one given in the tables. r, r', and the Thompson ammeter were each read fifty times, and values in the tables are in every case the average of fifty observations. By laying off the diameter in mils. as abscissæ and the temperatures as ordinates we get a curve representing the desired relations.

Another set of experiments had for its object the determination of the effect of an insulating covering upon the temperature which a current would maintain. In order to have as few inaccuracies as possible, Professor Anthony obtained, through the courtesy of the manufacturers, wire in lengths of about 100 feet, of which half of each size was covered with their ordinary insulating material, the other half being left bare. The dimensions given are the average of ten readings on the micrometer screw gauge reading to tenths of a mil., and the values of r, r', and the reading of the ammeter are the averages of thirty observations. Deductions from the results are made later, after the theoretical discussion of this problem has been given.

Having given the data of experiments and the results derived therefrom, it now remains to compare these results with those obtained from theoretical considerations or by other experimenters. From the definitions of the C.-G.-S. system of electrical units, one volt-ampere or watt $=10^7$ ergs $=\frac{1}{9\cdot81}$ kilogrammetres. But $c\,e=c^2\,r$; hence the work done by a current, c, in passing through a resistance, r (c in amperes and r in ohms), $=c^2\,r$ watts $=\frac{C^2\,R}{9\cdot81}$ kilogrammetres per second. Since this energy is all converted into heat, we have the heat developed in a conductor $=\frac{C^2\,R}{9\cdot81}$ kilogrammetres $=\frac{C^2\,R}{9\cdot81\times\cdot424}$ calories, since one calorie (lesser) equal ·424 kilogrammetre.

(To be continued.)

SELECTED CORRESPONDENCE.

[The following further correspondence has appeared in *The Times* on the question of "Judges and Patents."—ED. *E.*]

Mr. Imray's eagerness on the one hand to prove that judges are quite justified in the practice of giving a wider interpretation to patent claims than the language of the claims warrants, is only equalled by the anxiety which, on the other hand, he exhibits to prove that no such practice as the judicial warping of patents exists. He is very desirous indeed to defend the judges, against whom, however, I have made no other accusation than that, to adopt Mr. Imray's own expression, they have been "bamboozled" by professional experts. "If I have sinned," says Mr. Imray, "it has been in good company." Precisely so. In company with experts and counsel who have bamboozled judges into declaring that billiard balls are compressed to half their diameter in falling on a table, that electric light carbon is a semi-conductor of electricity, that leaving a clearance between the piston and cylinder end of a gas engine is an important novelty of construction, and such other deliverances. But I take Mr. Imray again at his word. He says, "in dealing with an invention of a fundamental character judges properly give a wider interpretation to patent claims than when they have to deal with a mere improvement in the details of known inventions." That is a perfectly clear statement of a practice which Mr. Imray holds to be just. I hold it to be essentially unjust to the public and to other inventors. If the invention is so very fundamental let the inventor make a broad fundamental claim; no one can object to that. But it is quite another matter if the inventor draws a mere detail claim. If he, having made a fundamental invention, only draws a detail claim, what right has any judge or bench of judges to stretch that claim beyond what the inventor has claimed as his own? I fail to see the justice of giving to any inventor anything more than the words of his claim, whether wide or narrow in their effect, entitle him to.

But letting even that pass, I say emphatically that, whatever the justice or injustice of this proceeding, there cannot be two opinions as to the justice or injustice of the proceeding by which the inventor of a mere improvement in detail is held up by experts and counsel, as the great and original inventor of a fundamental invention of absolute novelty, in order to procure in his favour the judicial benefit of having his patent stretched. That is one form of the practice of bamboozling that is at present tending

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to bring the administration of patent law into grievous disrepute. Experts and counsel unite in representing Otto as the great inventor of gas engines and gas engine principles, in spite of the facts that the gas engines of Huzon and of Lenoir were at work years before, and that Otto merely introduced certain improvements some of which were of more than questionable novelty. The Court, impressed by the magnitude of the person thus held up as the original inventor, decided every point in favour of Otto, benevolently stretching doubtful points in his favour. Similarly experts and counsel foisted upon Mr. Justice North the notion that there were no telephones before the date of Edison's specification, oblivious of all the telephones of Reis, of Elisha Gray, of Varley, and of Graham Bell. Their object in doing this was of course to take advantage of the "benevolent construction" put by judges upon the claims of fundamental inventors, and their success showed their consummate knowledge of the ways of Courts. Poor Mr. Justice North fell into the trap, and declared that Edison—not Reis, nor Varley, nor Graham Bell, nor Elisha Gray—was the true inventor of the telephone, and he did not hesitate to stretch everything in his favour, even going so far as to declare that a tube was a diaphragm because it could vibrate! This was a point, however, which the Court of Appeal was too wise to confirm, and which with grim humour it declares it will consider when the case arises. In this instance, perhaps the most glaring that has recently occurred, the invention which was thus professionally distorted into the original and fundamental invention of the telephone, was literally a mere improvement in detail. A telephone consists necessarily of at least three parts; a transmitting instrument, a circuit, and a receiving instrument. Edison's sole claim was for improvements in the transmitting part; and it related only to one of the three possible kinds of transmitters, namely, that kind which works upon the principle of variations in the resistance of the circuit. It was therefore only a detail of a detail; and so far as there was any general principle in it, in the application of the principle of variations of resistance, that general principle was in terms disclaimed by its inventor. The one claim is for a "combination"—the mere putting together of two things, the "diaphragm or tympan" and the "tension-regulator," both of which things were old, and for which the inventor does not now make any separate claim! This device of putting together two old and well-known things to make a new "combination" is a favourite one with inventors, especially with American inventors; and I am not going to say that there is no merit in new combination. But in this case not even the combination itself was novel, inasmuch as there had been shown years before by Philip Reis a telephone transmitter having a diaphragm or tympan of bladder in combination with a platinum tension-regulator, which is identical in its mode of action with the platinum tension-regulator described in Edison's specification. Moreover, there had been shown at the Philadelphia Exhibition of 1876 another instrument having in it a liquid tension-regulator identical with one of those described in Edison's specification, combined with a diaphragm. How, in view of these things, even a professional expert can maintain that Edison's "combination" was an invention so great and glorious that language must be warped and common sense violated in order to do justice to its "fundamental character," it is difficult to understand. But Mr. Imray goes even further than the judges. Says, Mr. Imray: "So long as 'in an instrument for transmitting electric impulses by sound' there is the combination of something that vibrates to the voice and by its vibrations acts on something which 'varies the resistance in a closed electric circuit,' that instrument is *obviously* within the scope of Edison's claim." Here is patent stretching with a vengeance. Although Edison had declared his diaphragm or tympan was to be, as his drawings also showed, "like a drum," Mr. Justice North declared that a wooden tube was a diaphragm because it could perform the functions of a diaphragm! The Appeal Court, happily for its own reputation, did not confirm that dictum. But now we have Mr. Imray stretching the plain term diaphragm so as to include anything that vibrates to the voice—say, a dewdrop, a candle flame, or the air itself—for they all come within Mr. Imray's definition, though they are none of them "like a drum." I can only ask which is right, Mr. Edison, the inventor, who says that the diaphragm or tympan must be like a drum, or Mr. Imray, the expert, who says it must be "something that can vibrate to the voice," whether like a drumhead or not? We have Mr. Imray's word for it that diaphrapms and tympans, and "indeed objects of all kinds," can vibrate to the voice. Mr. Imray is not going to say that objects of all kinds are diaphragms because they can vibrate to the voice. Mr. Imray is very desirous of defending Lord Justice Cotton for having—as reported in *The Times*' report of the suit of the United Telephone Company *v.* Bassano—declared that amongst Edison's tension regulators the one ultimately adopted was one consisting of "carbon blocks" and "suspended pencils of carbon." I had pointed out that no such things were described in Edison's specification, but that these words described Hughes's microphone, which was only invented in 1878, the year after Edison's specification. In defence of Lord Justice Cotton Mr. Imray coolly makes a new definition of the term microphone to suit the case, and also quotes from Edison's specification a passage in which neither "carbon blocks" nor "suspended pencils of carbon" are mentioned. Would Mr. Imray, who is so anxious to justify Lord Justice Cotton in this matter, having put Hughes's microphone of 1878 into Edison's specification of 1877, be surprised to learn that Lord Justice Cotton did not do anything of the kind? I stated that this was what had occurred if *The Times*' report be correct; and having since seen the verbatim judgment of Lord Justice Cotton I have ascertained that the impression conveyed by the necessarily brief abstract in the law report of *The Times* is not justified by the words of the learned Lord Justice Cotton. I have reserved to the last Mr. Imray's new definition of the microphone, because it is a fine example of the very practice of which I complain, the stretching of patents on expert testimony. "What is a microphone," asks Mr. Imray, "but 'an instrument in which semi-conducting material' is arranged in a 'telegraphic circuit' in connection with a 'a diaphragm,' so that there is a variable resistance resulting from 'greater or less intimacy of surface-contact' produced by minute vibrations of the diaphragm?" It is a magnificent definition, but, unfortunately, not correct. Does not Mr. Imray remember how, in 1878, Prof. Hughes took the Royal Society and the Society of Telegraph-Engineers by storm when he showed that a microphone consisting of three French nails, or of a gold chain, or of three little bits of good conducting gas carbon, would transmit speech and even the most minute sounds perfectly well without any semi-conducting material or any diaphragm or drumlike thing of any kind! Does he not remember how it astonished everybody that no diaphragm was necessary—that the microphone might be placed directly upon the works of a watch, or upon the speaker's throat, or even on the top of his head? Does he not remember how Mr. Edison instantly cabled across the Atlantic that his invention had been pirated, and was so exceedingly anxious to prove that he, not Hughes, was the inventor of the microphone, that he wrote off in hot haste to the *New York Tribune*, declaring that he, Edison, had discovered some months before that he "could dispense with the vibrating diaphragm?"

Yet now Mr. Imray speciously puts back the vibrating diaphragm into the definition of the microphone—and why? In order to demonstrate triumphantly, as he thinks, that the Hughes microphone was included in the one combination that Edison can claim. Again, I can only ask which is right; Mr. Edison, the inventor, who, in order to gain credit for the discovery of the microphone, declares that a microphone has not a diaphragm, and that he discovered that it did not require one after he took out his patent, or Mr. Imray, the expert, who, in order to drag the microphone into Edison's patent, declares that a microphone must have a diaphragm?

I am extremely indebted to Mr. Imray for such an apt illustration of the expert method of distorting language, though happily, in this case, he will not bamboozle the court of public opinion into a mistaken judgment.

I am, Sir,

Yours faithfully,

(Signed) SILVANUS P. THOMPSON.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. AUG. 18.		BUSINESS DONE WEEK ENDING AUG. 18. Highest.	Lowest.
Anglo-American	33,	34	33½	33
Do. Preferred	55,	56	55⅝	54½
Do. Deferred	11,	11½	11⅝	11
Brazilian Submarine	10½,	10½	10½	10 5-16
Cuba	11,	11½	11⅝	11½ xd.
Do. Preference	18,	19	18⅝	18½ xd.
Direct Spanish	1½,	2	1⅞	—
Do. Preference	9,	10	9⅝	—
Direct United States Cable	9,	9½	9⅝	—
Eastern Telegraph	11½,	11⅝	11⅝	11½
Do. 6 per Cent. Preference	14½,	14⅞	14⅝	—
*Do. 5 per Cent. Debentures, 1899	105,	108	—	—
Eastern Extension	12⅛,	12⅜	12⅜	12 3-16
German Union	9½,	9⅞	—	—
Globe Telegraph and Trust	6½,	6⅝	6⅝	6½ xd.
Do. Preference	13½,	13⅝	13 7-16	13½xd.
Great Northern	12½,	12⅞	12⅝	—
Indo-European	36,	37	—	—
Reuter's	6,	6½	6⅝	—
Submarine	90,	200 xd.	—	—
West India and Panama	⅝,	¾	13-16	—
Do. 1st Preference	8¾,	9½	9½	8 15-16
Western Brazilian	6¾,	7	7	6 15-16
Western Union 7 per Cent. 1st Mortgage	118,	122	—	—
Do. 6 per Cent. Sterling Bonds	103,	107	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	13-16	15-16	—	—
Oriental	3-16	5-16	—	—
United Telephone	13½,	13⅞	13⅞	13 9-16

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	2,	2½	—	—
Do. (fully paid)	3½,	4½	—	—
Swan	⅜,	1½	—	—
Maxim Weston	3-16	5-16	¼	—

MISCELLANEOUS.

Telegraph Construction	37½	38½	38	37½
India Rubber, Gutta Percha, and Telegraph Works	23	24	23¾	23½

TRAFFIC RECEIPTS FOR JULY, 1886.

COMPANIES.	July, 1886.	July, 1885.	Increase.	Decrease.
Cuba Submarine	2,800	2,517	283	—
Direct Spanish Telegraph	1,270	1,284	—	14
Eastern Extension	34,931	46,099	—	11,168
Eastern Telegraph	43,703	48,081	—	4,373
Great Northern	23,000	—	—	—
West Coast of America	3,050	—	—	—

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NOTES.

CHILI.—The theatre at Valparaiso is now lit by incandescent light.

BERLIN.—The University of Berlin is to be provided with 600 incandescent lamps.

INDIA.—Telephonic communication is about to be adopted for station to station signalling on the Madras Railway.

THE TELEPHONE IN GERMANY.—There are now 68 telephone exchanges in the German Empire, with a total of 12,328 subscribers.

LOCOMOTIVE HEAD LIGHTS.—Several of the leading railroads in the United States are about to adopt electric headlights as part of their equipment.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the weeks ended 13th and 20th inst. amounted to £3,309 and £3,326 respectively.

SAFETY LAMPS IN MINES.—The *Colliery Manager*, commenting upon the disastrous explosion at Leigh, expresses an opinion that the adoption of the electric light should at once be made compulsory in all mines.

PREVENTION OF FORGERY.—A letter appears in the *City Press* from Mr. R. Herring, on the subject of forged bank notes. Mr. Herring is the inventor of an electrical method of water-marking, which renders forgery difficult if not impossible.

WAY-LEAVE.—The Brooklyn Bridge Administration makes a good thing out of the annual toll charged for each wire laid along the bridge. Last year it received £1,790 from this source. The total number of wires crossing the bridge is now 292.

CHINESE TELEGRAPHS.—It is stated that the Chinese are extending their telegraph line from Wuchang, on the river Yangtzi, to the city of Yunnan, the capital of the province of the same name. This line will be completed about the end of the present year.

PERSONAL.—Mr. Allen, General Superintendent of Telegraphs of the Argentine Railway, has retired after 20 years service, in which he has brought the department into a state of great efficiency. Mr. Allen leaves the country amid general expressions of regret.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the weeks ending 13th and 20th inst., were £2,532 and £1,913, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

A CENTRAL STATION IN PARIS.—It is reported that a central station for the supply of electricity is about to be established in Paris, in the neighbourhood of the Porte St. Martin. Two theatres and a considerable number of private establishments are already on the list of consumers.

SUGAR BY ELECTROLYSIS.—It is stated that at Lyons a process has been introduced by which both glucose and sucrose can be separated by electrolysis. It is also said that the process is sufficiently economical to render it available for the extraction of sugar from potatoes as well as from beetroot.

THE AMERICAN EXHIBITION OF 1887.—We are told that the President of the United States has consented to open the forthcoming American Exhibition *by telegraph*. Our Yankee friends will probably take this opportunity of arranging for something which the general public will regard as "sensational."

FIRE ALARMS.—A system of electric fire alarms has been in operation for some time in Paris, and has given such satisfaction that it is about to receive a very considerable extension. It is also intended to establish a school for the instruction of the firemen in the duties required for the maintenance of the system.

PARIS.—The Municipality of Paris has taken into consideration the means of supplying motive power to small artisans at their own dwellings. Two schemes are before them, one based upon the employment of compressed air, and the other making use of a "vacuum" motor. Electricity does not appear to have been suggested.

LA ROCHE-SUR-FORON.—The central lighting station at this town, which has just been completed by M. Sansoube, has been taken over by a newly formed company, entitled the Société Lyonnaise d'Electricité. This company proposes to undertake electric lighting upon a large scale at Lyons and in the neighbouring towns.

THE LALANDE BATTERY.—We are informed that the Standard Electric Light Company, which owns this battery, during the last twelve months has completed and maintained installations in two or three establishments in the City, as well as in several country houses, in addition to those which we mentioned in a recent issue.

DEODORISING SEWER GAS BY ELECTRICITY.—Mr. Hartley Fewson has recently devised a process for "the withdrawal and destruction of sewer gas by electrolysis." The invention seems to be of a practical character if we may judge by the encomiums passed upon it by several sanitary inspectors, medical officers of health, and others.

THUNDERSTORMS.—Severe thunderstorms continue to be reported from various parts of the Continent. At Presburg the palace of the Archduke Frederic was struck; the discharge actually passed through the room where the family were seated, and did a great deal of damage to the furniture, but fortunately no personal injury was inflicted.

TELEPHONE EXTENSION IN BELGIUM. — The Belgian Government has established a telephone exchange at Ostend with a trunk line to Brussels. The rate of subscription is 170fr. per annum for the first kilometre, and 17fr. 50c. for each half kilometre beyond the first. Public stations are open at a charge of 25c. for ten minutes' conversation.

THE PARIS EXHIBITION OF 1889.—It is asserted that the General Secretary of this Exhibition estimates that the electric lighting of the buildings will absorb 25,000 horse-power. Allowing one-half for arc lights and the remainder for incandescents, this would be equivalent to more than 30,000,000 candle-power! We must decline to vouch for the accuracy of our information.

A LOUD-SPEAKING TELEPHONE.—The firm of Hartmann and Braun are introducing a loud-speaking telephone, which seems to be a successful instrument. The result is attained simply by considering the diaphragm as a part of the magnetic circuit, and by arranging the poles of a double horseshoe magnet in such a way as to cause as many lines of force as possible to pass *through* the disc.

THE EDISON COMPANY OF BERLIN.—This company has just completed the reorganisation of their factory, and they now announce that they are prepared to supply lamps of from 5 to 100 candle-power at any required voltage from 1 to 120, guaranteed to consume energy at any required rate between 2 and 3·5 watts per candle. The capacity of the works is said to be equal to an output of 2,000 lamps per day.

TELEGRAPHS ON WEST AFRICAN COAST.—We are informed that the Silvertown Telegraph Company have received a

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telegram, announcing the completion of the Accra Porto Novo and the Porto Norvo St. Thomé sections for the West African Telegraph Company. These stations, and that of the Grand Bassam, will be opened on the completion of the Sierra Leone Accra section, which it is expected will shortly take place.

THE BRITISH ASSOCIATION.—Although the presidential address at the forthcoming meeting of the British Association is scarcely likely to deal at any length with electrical science, it has always been our custom in the past to reproduce this address, and it is probable that we shall do so this year. From the programme already announced it seems probable that the Birmingham meeting will in all respects be a highly successful one.

A BELGIAN INSTALLATION.—The residence of M. Montefiore, at Esueun, is lit by 200 incandescent lights. The motive-power is obtained from a Parson's high-speed engine of 18 horse-power. This engine drives a Victoria dynamo, and the latter charges a secondary battery of the Jullien type. M. Montefiore is himself an electrician and possesses a well appointed laboratory, which is warmed as well as lighted by electricity.

DIRECT COMMUNICATION BETWEEN LIVERPOOL AND HAVRE. The Liverpool Chamber of Commerce some time since petitioned the Post Office to give them direct telegraphic communication with several towns upon the Continent. The Post Office has now replied that they find that the amount of traffic would only justify such an arrangement in the case of Havre; and that they hope in this instance to be able to carry the wishes of the Chamber into effect.

A NEW INSULATING MATERIAL.—We recently gave some account of the electric tramway at Hamburg. An interesting feature which we omitted to mention is the fact that a new material has been adopted for the construction of the accumulator cells. This substance, which at present does not appear to have received any distinctive name, is said to have a higher insulation resistance than ebonite, and at the same time to be of lighter weight, more highly flexible, and of greater strength than that material.

NEW ARC LIGHTING SYSTEM.—To the number of American companies owning or working complete systems of arc light illumination must now be added the "Tesla Electric Light Company." It is claimed that the self-regulation of their dynamo is obtained by means of an "entirely novel principle" which does not involve any reaction detrimental to the output of the machine. We cannot attach much importance to a statement of this kind in a mere prospectus, but if it can be substantiated this should prove both interesting and important.

WHERE ARE THE ELECTRIC LIGHT COMPANIES?—Under this heading a correspondent from Spain sends us the following note, which certainly indicates a somewhat archaic state of things in that country:—"Villa Real has been *en fête!* A band has been parading the town! The Governor of the province has been entertained at a luncheon, and the priest has blest the ceremonial. This enthusiasm has been evoked by the inauguration of a gas works (!) Many other towns are tired of the oil lamps of their grandfathers. The only alternative offered them is gas."

THE SOMZÉE INCANDESCENT LAMP.—The Belgian electricians have recently been engaged in a somewhat warm controversy over the question of precedence in the invention of the incandescent lamp as between Somzée and Edison. Without prejudice to this particular dispute we cannot help fearing that there will soon be almost as many claimants for incandescent lamp patents as there are original inventors of the telephone. One of the American journals recently published as "startling intelligence" the fact that no new "original inventor" of the telephone had appeared for nineteen days.

COMING INSTALLATIONS.—We are informed that Mr. H. Bury, electric light engineer, Manchester, has received instructions to light up the following, viz.:—Messrs. Dickens and Co., dye house, &c., Middleton; Messrs. Walker and Carver, paper works, Pendleton; Messrs. J. King and Sons, weaving shed and spinning rooms, Rochdale; Messrs. W. Thompson and Sons, weaving shed and spinning rooms, Burnley. And also from the well-known firm of John Rylands and Sons (Limited) through Mr. Acheson, agent for R. E. Crompton and Co.'s dynamos, to light Swinton Mill, containing about 1,100 lights.

ELECTRICITY AND ROOT GROWING.—An ancient but interesting experiment showing the influence of electricity on the growth of roots has recently been repeated in Germany by Prof. Holdefleiss. Plates of copper were thrust upright into the earth, and connected by wires with similarly placed zinc plates about 100ft. distant—an electric battery being thus formed, with the earth between the copper and zinc in the circuit. It is stated that potatoes and beets planted between such plates gave an increased yield—beets 15 per cent., potatoes 25 per cent.—as compared with other parts of the same field.

THE EXPLORATION OF MINES.—At the scene of the recent accident, in which several quarrymen lost their lives at Chancelade, some of the deeper pits of the quarry, which remained inaccessible after the accident, were explored by means of a photographic apparatus to which an incandescent lamp was attached. The apparatus was lowered into the pit, and photographs were secured at different levels with the view of discovering any lateral openings in which the entombed miners might have taken refuge. The lamp was fed from a primary battery, and some very successful photos were secured.

ELECTRO-METALLURGY.—In a paper upon the application of electricity to metallurgy, contributed by M. Védrinsky to the *Moniteur Scientifique*, it is stated that in the electrolytic reduction of copper ore the presence of tin in the bath exercises a very beneficial influence. The copper deposited upon the cathode in the presence of tin is said to be of a uniform texture and of malleable quality. The resistance of the liquid is also said to be considerably reduced under these circumstances. Antimony produces the same result as tin. The effect of introducing other metals has been studied, but the results were in general either neutral or disadvantageous.

"FURTHER HISTORICAL NOTES ON THE ELECTRIC LIGHT." Under this heading a special number of the *Journal* of the Society of Telegraph-Engineers contains a continuation of the abstracts of patents connected with electric lighting, which have been prepared by Colonel Sir Francis Bolton, hon. secretary to the society. The previous papers of this series appeared in May, 1879, and in November, 1882. The latter brought the record down to within a few weeks of the date of publication. In the present paper the list is brought up to the close of 1885. This is a work which must have entailed a vast amount of labour, and is of incalculable value to all electricians who are in any way concerned in patents or inventions.

AUTOMATICALLY SIGNALLING TRAINS.—Not long since the *Societé d'encouragement pour l'industrie Nationale* offered a prize of 3,000fr. "for an apparatus strongly and simply made which should announce automatically and in a certain and regular manner the passage of a train in motion at any required dis-

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tance." M. Jourdain, without claiming the prize, has written a note to the society, suggesting that a telephone transmitter at the required spot would answer the purpose. We presume that M. Jourdain intends to employ some particularly loud-speaking receiver. In the event of the prize not having as yet been awarded we would suggest that an electric bell and a suitable mercury contact would seem to fulfil all the required conditions.

An Improved Speed Gauge.—The Compagnie Générale d'Electricité of Antwerp has introduced a modification of the well-known Hedges or Ramsbottom speed-gauge. The principal feature of novelty is that by means of an electric bell an alarm is given when the speed either rises or falls beyond certain limits. The arrangement is as follows:—(1) When the speed falls the depression of the central portion of the liquid decreases, contact is thus made with a metallic stem which projects into the centre of the cup; and (2), when the speed increases, contact is made by the upper surface of the liquid at the side of the cylinder, the upper part of which is insulated from the lower. There is also an ingenious arrangement for driving the containing vessel either from the top or the side of the shaft whose speed is to be measured.

Long Distance Telephony in the Western Counties. From information furnished us by the Western Counties and South Wales Telephone Company, we gather that exchanges have up to the present been established by this Company in the following towns:—Bristol, Plymouth, Torquay, Portsmouth, Bournemouth, Cardiff, Newport, Southampton, and Bath. To this list Worcester, Exeter, and Swansea will shortly be added. The following trunk lines are in working order:—Bath and Bristol, Cardiff and Newport, Bournemouth and Poole, Torquay and Paignton. By the end of October Bristol will also be placed in communication with Newport, Cardiff, and Swansea, and Worcester with Great Malvern. It is also intended, if the new exchange at Exeter proves to be a success, to connect that city with Bristol and with Plymouth.

Covent Garden Lighting.—The electric lighting for the Promenade Concert season at Covent Garden Theatre is being this year carried out by Messrs. Paterson and Cooper, on a more magnificent scale than in former years. The power is supplied by a 30 horse-power nominal Marshall's engine driving on to a counter shaft from which are run the five dynamos supplying the current. Of these, three are arc machines, giving 8 amperes at 700 volts, but only two are used for the lights, the third being kept as spare. The two remaining machines for the incandescent lighting are of 300 and 200-light capacity respectively. Twenty-four Pilsen lamps, as constructed by Messrs. Paterson and Cooper, are employed for the arc lighting. The incandescent lamps are 446 in number, and the interior of the theatre presents a most brilliant appearance.

Industrial Exhibition at Birmingham.—An Industrial Exhibition of an interesting character will be opened to-day at the Bingley Hall, Birmingham, in connection with the approaching meeting of the British Association in that town. The exhibition is intended to show visitors the varied industries of the town and its neighbourhood, and this it will do most effectually. Industrial exhibits are confined to a radius of 15 miles of Birmingham, and specimens of natural history, botany, and geology collected within 20 miles of the borough. At night the entire building will be illuminated by electricity. The exhibitors are 254 in number, and comprise among them nearly all the leading names of Birmingham industry. The mayor, Alderman Martineau, will open the exhibition to-day, and it is understood that he will be accompanied by Sir William Dawson, the president of the British Association.—*The Times.*

Telephonic Extension at Bradford.—There has just been opened a trunk wire connection between Bradford and other West Riding towns which are comprised within the district of the National Telephone Company and the Manchester exchange of the Lancashire and Cheshire Telephone Company. The *Bradford Observer* says:—"At present two wires have been completed, but three others are only wanting a short link to perfect the connection. We (*Bradford Observer*) yesterday evening (23rd inst) had an opportunity of speaking with Manchester from the *Observer* office, and the telephone worked admirably. It will now be possible for every subscriber on the Bradford exchange to talk through the Manchester exchange to Manchester, Liverpool, Blackburn, Bolton, Burnley, Southport, Blackpool, and other Lancashire towns. This extension of the telephone will doubtless lead to the more general adoption of the system."

The Indian Telegraph Department—On Monday last Mr. Conybeare asked the Under Secretary of State for India whether any and what steps had been taken to remedy the admitted grievances of the officers of the Indian Telegraph Department; and whether he would lay upon the table of the House the whole of the correspondence that had been passed on this subject, as well as between the Director-General of Telegraphs and the Indian Government as between the latter and the India Office.—Sir J. Gorst replied that a scheme relating to the Telegraph Department in India was prepared by the late Secretary of State in Council and transmitted to India on July 8th. The Government of India was authorised to give effect to it if, after obtaining the views of the Commission which has been appointed to consider the possibility of effecting reductions in the public expenditure, they should think it right to do so. Until the decision of the Government of India has been received it is impossible to undertake to publish the correspondence.

Electrical Foot Warmers.—The acetate of soda foot warmers now used for railway carriages gradually become cool by radiation; but M. Tommasi, the French electrician, proposes to keep them up to a certain temperature by means of the heat due to an electric current traversing a high resistance. Only the heat lost by radiation is thus compensated for, so that the original high temperature is obtained on the cheaper plan of heating by a fire, or rather by plunging the warmers in boiling water. The current employed to maintain their heat is to be supplied by a dynamo driven off an axle of the train, and the circuit passes through all the warmers. A simple device allows of the foot warmer being thrown out of circuit should it become unbearably hot. The plan will require fewer foot warmers than are now used, since it will be unnecessary to change them during a lengthy journey. This combination of fire and electric heating is perhaps more likely to be successful for the present than a purely electrical arrrangement. Most of the latter which have been devised are of feeble power. *Engineering.*

Bernstein's New Filament.—Mr. Alexander Bernstein has succeeded in producing a carbon filament by a novel and interesting process. He takes a vessel containing a liquid hydro-carbon or some other carbon compound, such as the bi-sulphide. In this liquid he suspends a fine metallic wire while a copper plate is placed at the bottom of the vessel. He then passes a current through the liquid from the wire to the plate. This determines the decomposition of the hydro-carbon and the growth of a hard and dense deposit of carbon upon the

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end of the wire. By means of a clockwork attachment, the wire is gradually withdrawn at a suitable rate of motion, and in this way a filament of any desired length can be obtained. The cross-section of the deposit is regulated by adjusting the strength of the current and the size of the wire. By employing two wires as electrodes, and an alternating instead of a continuous current, two filaments are produced at one operation. One would imagine that the process might be carried out upon a large scale by employing a sufficiently large current and grouping the filaments in parallel.

ELECTRIC PHOTOGRAPHY.—Dr. Boudet has presented to the *Société Internationale des Electriciens* an account of a series of experiments with which he has recently been occupied, and which has led him to devise an interesting method of reproducing designs of a certain class by electricity. Dr. Boudet builds up a condenser, of which a single sheet of metal forms one coating, a gelatino bromide film, mounted on glass, in the usual way, forms the dielectric, and the object whose image is to be taken occupies the place of the second coating. If this object be not a conductor a sheet of metal is placed behind it. The condenser is then charged from a Voss machine, or other source of high tension electricity. After discharge the plate is developed in the usual way, and the photographic image is found upon its surface. The most suitable objects for this treatment are metallic plaques, either engraved, etched, or stencilled; but by means of placing a second metallic surface at the back Dr. Boudet has obtained very fair pictures of ivory miniatures and similar objects, and he has even reproduced pen and ink drawings with some degree of success.

LEEDS MUSICAL FESTIVAL.—The arrangements for illuminating the Victoria Hall for the purposes of the Musical Festival are still incomplete. The Electric Lighting Committee of the Corporation, it may be remembered, recently experimented with a number of arc lamps, for which electricity was supplied by engines belonging to the borough in the base of the Municipal Buildings. The Festival Committee have seen these lamps tried, and have come to the conclusion that they do not seem to be so likely to serve the purpose as the electroliers of Messrs. Crompton, by means of which the hall was artificially illuminated at the last festival. The Festival Committee, anxious again to secure the adoption of the Crompton system, have offered the Electric Lighting Committee £100 towards the cost of lighting the hall by this method for the festival. Apparently wishful, if possible, to meet the desire of the Festival Committee, the Electric Lighting Committee have asked Messrs. Crompton what they would charge to put the old electroliers into working order, and to light the hall with them for the festival, the power and other apparatus of the Corporation to be used. There the matter now stands.—*Yorkshire Post*

THE SUBMARINE TELEGRAPH SYSTEM.—A correspondent writes to *The Times* from Copenhagen, Aug. 21:—"Mr. John Pender, who is at present on a visit to Denmark, was last night entertained at a large banquet by Mr. Tietgen and the directors of the Great Northern Telegraph Company. Many distinguished citizens were present, including the Minister of Marine and Sir Edmund Monson, the British Minister. In concluding an able and cordial speech, Mr. Tietgen, in alluding to the fact that to England and Denmark was mainly due the credit of carrying out the great submarine telegraph system which now brings the civilised world into daily communication, and to the part borne by Mr. Pender in its initiation and development, paid him the graceful compliment of offering him the telegraphic championship of the world. In replying, Mr. Pender emphasised the great and growing importance of the system, which was now playing such an important part both in political action and commercial development, and stated that those entrusted with the direction of the submarine telegraphs were unanimous in their desire to provide all possible facilities, and thus extend and increase its usefulness and value to the world at large."

ANCIENT ELECTRICAL LITERATURE.—It is not, perhaps, generally known that among the distinguished men who have written upon the subject of electricity we should recognise Marat. In 1779 he published a pamphlet, entitled "Découvertes sur le feu, l'electricité et la lumière," and a little later appeared his "Recherches sur l'electricité," a handsome volume, illustrated with woodcuts. About the same date a work was printed in Berlin with the title "Physica mystica, Physica sacra, sanctissima." At the beginning of the last century the world was enlightened by the publication of a voluminous work in quarto under the title of "Dissertatio de Nocti luca Mercuriale seu de luce quam argentum vivum in tenebris fundit." But one of the strangest contributions ever made to the literature of science was contained in Johan Hartmann's *De Electricitate psittaci plumæ notata quadam* (on the electricity of a parrot's wing). In No. XXIII. of the *Phil. Mag.* is a paper "On a Galvanic Battery composed exclusively of Beans." A vast amount of nonsense has been written about electricity as a curative agent—John Wesley wrote a treatise on the subject—but, on the other hand, in 1840 Sir James Murray published a tract, entitled "Electricity as a Cause of Cholera and other Epidemics." This list (the greater part of which is taken from *L'Ingenieur Electricien*) might of course be extended *ad nauseam*.

AUTOMATIC FIRE EXTINGUISHERS.—At the meeting of the Balloon Society on the 20th inst., a paper was read by Mr. H. Stokes, F.G.S., upon the Percival Automatic Fire Extinguisher. This system depends in part upon an electric arrangement which is brought into operation by the melting of a plug of fusible metal. A somewhat similar arrangement has been introduced to the notice of the International Society of Electricians by Messrs. Thetinet. This consists of a cable for telephones and bells, which at the same time forms an automatic fire alarm. This cable is formed of two copper wires, covered in a special manner with a thin coating of a fusible metal. One is insulated by gutta percha, the second is simply glued to the first. They are then united by twisted cotton, and covered by thick gutta percha, and finally by an outer coating of cotton or silk. This wire may be carried around the building wherever a fire is specially to be feared. The daily use of the circuit will ensure that it and the batteries are always in working order; this presents an advantage over those apparatus which are used for fire alarms only. If a fire occurs, the double envelope of gutta percha and cotton being very combustible, the heat lays bare the two conductors and melts the fusible metal coating. In melting, this metal makes contact between the wires all along the part burnt, which closes the circuit of the battery, and sets the bells ringing.

THE TELEPHONE IN 1664.—The following remarkable paragraph occurs in the works of Robert Hooke, published in 1664. Hooke assisted Robert Boyle in his famous experiments, and was appointed curator and afterwards secretary to the Royal Society:—"And as glasses have highly promoted our seeing, so 'tis not improbable but that there may be found many mechanical inventors to improve our other senses of hearing, smelling, tasting, touching. 'Tis not impossible to hear a whisper a furlong's distance, it having been already done; and perhaps the nature of the thing would not make it more impossible though that furlong should be ten times multiplied. And though some famous authors have affirmed it impos-

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sible to hear through the thinnest plate of Muscovy glass, yet I know a way by which it is easy enough to hear one speak through a wall a yard thick. It has not yet been thoroughly examined how far Otocousticons may be improved, nor what other ways there may be of quickening our hearing, or conveying sound through other bodies than the air; for that is not the only medium. I can assure the reader that I have, by the help of a distended wire, propagated the sound to a very considerable distance in an instant, or with as seemingly quick a motion as that of light, at least, imcomparably swifter than that, which at the same time was propagated through the air; and this not only in a straight line, or direct, but in one bended in many angles."

THE PUBLIC LABORATORY AT MUNICH. — From the *Centralblatt für Electrotechnik* we learn that the electrical laboratory, which has been established at Munich by the Bavarian Government, will undertake the following duties:—(1). Experiments will be carried out at the request of any private individual, and at such charges as may be separately arranged in each case. The results of this class of experiments will be kept strictly secret. (2). Experiments upon industrial products which are brought to the laboratory to have their electrical properties tested. These tests are made gratuitously; the results, if of general interest, will, as a rule, be published; but if the client should formally express his desire for secrecy the publication may be withheld. (3). Experiments initiated by the staff of the laboratory, the results of which will be published at convenient intervals. The laboratory will be able to undertake experimental work relating to any of the following subjects:—Dynamos and motors, arc lamps and carbons, incandescent lamps, regulators of current and similar apparatus, transformers, galvanometers, voltmeters, ammeters, resistance boxes, primary and secondary batteries, thermopiles, wires, cables, and insulators, and also processes connected with electrolysis. The laboratory will also be prepared to undertake tests upon any established circuits, either for telegraphs, telephones, or electric lighting, or for lightning conductors. It is further proposed to establish a technical museum, and contributions either of money or of exhibits for this purpose will be welcomed.

AT HOME AND ABROAD.—The following letter has recently appeared in the *Birmingham Daily Post*:—"I wish to draw attention to the fact that English travellers, as soon as they leave their own shores, discover how very far behind other countries we are in the matter of the electric light. They see that the chief cities in France, Belgium, Holland, and Italy are so lighted. The traveller to America, on leaving the shores of the Mersey, finds himself, when the sun disappears below the horizon, in presence of electric light whilst enjoying his first dinner on board. If he land at New York by night he sees this illuminant in steamer and railway depôts, in the streets, squares, public buildings, stores (shops), hotels—everywhere. In the New York hotels where I sojourned the dining rooms and passages were so lighted, the machinery for producing the light being in the basement. The same thing may be said of all the chief cities, and of some at least of the smaller ones, in the States. Salt Lake City, which contains only 27,000 inhabitants, has its electric light both in streets and houses. The statement, therefore, that electric light is simply the "light of luxury," and nothing more, must, I submit, be regarded as a fallacy. It may also be safely asserted that the knowledge of the science of lighting by electricity is sufficiently advanced at the present moment, not only for purposes of luxury, but also for the production of a useful and economical luminant. The true reason why on this point we are so far behind other countries probably is the tenderness of our legislators for vested interests."

TINNED IRON.—A writer in *Industries* makes the following observations upon the subject of the regeneration of tinned iron. After describing the precautions necessary in the acid process, he proceeds:—"Persons in the trade say that the metal is injured by absorption of the acid, and affirm that occasionally it is necessary to repeat the annealing in order to remove rottenness engendered in this manner. To the writer it appears more probable that the effect is due to occlusion of hydrogen, for the iron can scarcely be porous enough to absorb the liquid, while the power of occluding gases is a well known property of iron and some other metals. If a piece of sheet iron be immersed for some time in hydrochloric (muriatic) acid, and then be well rinsed in a stream of water for half a minute, and the acid thus removed from the surface, careful observation will reveal an interesting phenomenon. For some time after the washing, minute bubbles may be seen bursting through the film of water left upon the iron, and the sound of effervescence may be heard if the metal be held near the ear. This is probably due, not to any evolution of hydrogen by acid, since this has been removed by washing, but to the escape of hydrogen from the pores of the iron. Producers of wrought iron say that the scrap stripped by acid always makes inferior iron if mixed in any considerable proportion with new metal. Yet this tin plate is rolled originally from good iron, and can be made so again if suitably treated. The reason, doubtless, is to be sought, not in the imperfect removal of tin, as often stated, but in the occlusion of hydrogen gas." If this view be correct it is probable that the hydrogen could most speedily be removed in an electrolytic bath, containing a suitable oxidising agent in which the iron was made the positive electrode.

TRANSMISSION OF POWER IN SWITZERLAND.—At Uster, in Switzerland, a very successful application of the electric transmission of power has been in operation since January last. The generator converts about 12 horse-power into electricity, and about 7·3 horse-power is obtained upon the shaft of the motor, showing an efficiency of transmission of 61 per cent The line is rather more than one kilometre in length. The potential at the terminals of the generator does not exceed 350 volts. The speed of the motor is regulated by the introduction of resistance. The installation is not perhaps to be considered as affording an example of the most recent progress in this class of work, but its performance has given entire satisfaction to the owners. We also hear that a company is about to be formed in Switzerland, with a capital of one million francs, in order to develop the industrial resources of the country by the introduction of electric transmission of power upon a large scale, and also for electric lighting. They have obtained a concession which will empower them to erect works at Montreux, where water power is abundantly available. It is intended to supply electric light to the district Vevey-Montreux, to supply motive power for domestic purposes, and to work an electric tramway 12 kilometres in length between Vevey, Montreux, and Chillon. This concession grants the company exclusive privileges for a period of fifty years. For a lamp of 14 candles it is contemplated to make a charge not exceeding 3·25 centimes per hour. The country to be traversed by the projected tramway has a population of 20,000, but it is also annually visited by thousands of tourists, and as the line runs through a very picturesque country by the banks of the River Vaudoin, and afterwards upon the shores of Lake Leman, there is every prospect of the undertaking proving thoroughly successful.

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ELECTROMAGNETIC INDUCTION AND ITS PROPAGATION.—XXXII.

BY OLIVER HEAVISIDE.

(Continued from page 297.)

The Equations of Propagation Along Wires.—Elementary.

In another place (*Phil. Mag.*, Aug., 1886, and later) the method adopted by me in establishing the equations of V and C, Section XXIX., was to work down from a system exactly fulfilling the conditions involved in Maxwell's scheme, to simpler systems nearly equivalent, but more easily worked. Remembering that Maxwell's is the only complete scheme in existence that will work, there is some advantage in this; also we can see the degree of approximation when a change is made. In the following I adopt the reverse plan of rising from the first rough representation of fact up to the more complete. This plan has, of course, the advantage of greater intelligibility to those who have not studied Maxwell's scheme in its complete form; besides being, from an educational point of view, the more natural plan.

Whenever the solution of a so-called physical problem has been obtained, according to which, under such or such conditions, such or such effects *must* happen, what has really been done has been to solve another problem, which resembles the real one more or less in those features we wish to study, which we regard as essential, whilst it is of such a greatly simplified nature that its solution is, in comparison with that of the real problem, quite elementary. This remark, which is of rather an obvious nature, conveys a lesson that is not always remembered; that the difference between theory and empiricism is only one of degree, even when the word theory is used in its highest sense, and is applied to legitimate deductions from laws which are known to be very true indeed, within wide limits.

It is quite possible to imagine the solution of the general problem of the universe. There does not seem to be anything against it except its possible infinite extent. Stop the extension of the universe somewhere; then, if its laws be fully known, and be either invariable or known to vary in some definite manner, and if its state be known at a given moment, it is difficult to see how it can be indefinite at any later time, even in the minutest particulars in the history of nations or of animalculæ, or in the development of a human soul (which is certainly immortal, for the good and evil worked by a soul in this life live for ever, in the permanent impress they make on the future course of events).

But if this be imagined to be all done, and the universe made a machine, no one would be a bit the wiser as to the reason why of it. (Even if we ask what we mean by the reason why, we shall in all probability get into a vicious circle of reasoning, from which there is no escape.) All that would be done would be the formulation of facts in a complete manner. This naturally brings us to the subject of the equations of propagation, for they are merely the instruments used in attempts to formulate facts in a more or less complete manner.

The first to solve a problem in the propagation of signals was Ohm, whose investigation is a very curious chapter in the history of electricity, as he arrived at results which are, under certain conditions, nearly correct, by entirely erroneous reasoning. Ohm followed the theory of the conduction of heat in wires, as developed by Fourier. Up to a certain point there is a resemblance between the flow of heat and the electric conduction current, but after that a wide dissimilarity.

Let a wire be surrounded by a non-conductor of heat, in imagination; let the heat it contains be indestructible when in the wire, and to be in a state of steady flow along it. If C is the heat current across a given section, and V the temperature there, C will be proportional to the rate of decrease of V along the wire. Or,

$$-\frac{dV}{dx}=RC,$$

if x be length measured along the wire. The ratio R of the fall of temperature per unit length, to the current, is the "resistance" per unit length, and is, more or less, a constant. Or, the current is proportional to the difference of temperature between any two sections, and is the same all the way between.

The law which Ohm discovered and correctly applied to steady conduction currents in wires is similar to this. Make C the electric current in the wire, and V the potential at a certain place. The current, which is the same all the way between any two sections, is proportional to their difference of potential. The ratio of the fall of potential to the current is the electrical resistance, and is constant (at the same temperature). But V is, in Ohm's memoir, an indistinctly defined quantity, called electroscopic force, I believe. Even using the modern equivalent potential, there is not a perfect parallel between the temperature V and the potential V. For a given temperature appears to involve a definite physical state of the conductor at the place considered, whereas potential has no such meaning. The real parallel is between the temperature gradient, or slope, and the potential slope.

Now, returning to the conduction of heat, suppose that the heat current is not uniform, or that the temperature gradient changes as we pass along the wire. If the current entering a given portion of the wire at one end be greater than that leaving it at the other, then, since the heat cannot escape laterally, it must accumulate. Applying this to the unit length of wire, we have the equation of continuity,

$$-\frac{dC}{dx}=\frac{dq}{dt},$$

t being the time, and q the quantity of heat in the unit length. But the temperature is a function of q, say

$$q=SV,$$

where S is the capacity for heat per unit length of wire, here regarded, for simplicity of reasoning, as a constant, independent of the temperature. This makes the equation of continuity become

$$-\frac{dC}{dx}=S\frac{dV}{dt}.$$

Between this and the former equation between C and the variation of V, we may eliminate C and obtain the characteristic equation of the temperature,

$$\frac{d^2V}{dx^2}=RS\frac{dV}{dt},$$

which, when the initial state of temperature along the wire is known, enables us to find how it changes as time goes on, under the influence of given conditions of temperature and supply of heat at its ends.

Ohm applied this theory to electricity in a manner which is substantially equivalent to supposing that electricity (when prevented from leaving the wire) flows like heat, and so must accumulate in a given portion of the wire if the current entering at one end exceeds that leaving at the other. The quantity q is the amount of electricity in the unit length, and is proportional to V, their ratio S being the capacity per unit length. With the same formal relations we arrive, of course, at the same characteristic equation, now of the potential, so that electricity diffuses itself along a wire, by difference of potential, in the same way as heat by difference of temperature.

A generation later, Sir W. Thomson arrived at a system which is formally the same, but having a quite different physical significance. Between the times of Ohm and Thomson great advances had been made in electrical science, both in electrostatics and electromagnetism, and the quantities in the system of the latter are quite distinct. We have

$$\left.\begin{aligned} -\frac{dV}{dx}&=RC, \quad q=SV,\\ -\frac{dC}{dx}&=\frac{dq}{dt}=S\frac{dV}{dt}, \end{aligned}\right\} \quad \frac{d^2V}{dx^2}=RS\frac{dV}{dt} \quad . \quad . \quad (71b)$$

where on the left appear the elementary relations, and on the right the resultant characteristic equation of V.

Here C is the current in the wire, R its resistance per unit length, and V the electrostatic potential. So far there is little change. But S is the electrostatic capacity per unit length of the condenser formed by the dielectric outside the wire, whose two coatings are the surface of the wire and that

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of some external conductor, as water, for instance, which serves as the return conductor. Thus S, from being in Ohm's theory a hypothetical quantity depending upon the nature of the conducting wire, its size and shape, has become a definitely known quantity depending on the nature of the dielectric, and its size and shape. Here is the first step towards getting out of the wire into the dielectric, to be followed up later. The equation $q = SV$ is the electrostatic law expressing the relation between the charge of a condenser and its potential difference, q being the charge on the wire per unit length, and V its potential. It is assumed that $V = 0$ at the outer conductor, which requires that its resistance must be very small, theoretically nothing. This makes V definitely the potential at the surface of the wire, and it must be the potential all over its section at a given distance x, if the current is uniformly distributed across the section.

The meaning of the equation of continuity is now that when the current entering a given length of wire on one side is greater than that leaving it on the other, the excess is employed in increasing the charge of the condenser formed by the given length of wire, the dielectric and the outer conductor. In the wire, therefore, comparing the electric current to the motion of a fluid, such fluid must be incompressible. It can, however, accumulate on the boundary of the wire, where it makes the surface charge. This is exceedingly difficult to understand. But in any case, whether electricity accumulates in the wire or only on its boundary, is quite immaterial as regards the form of the equation of continuity, and of the characteristic equation. (Of course it is the equations which give rise to it, and their interpretation, that are of the greatest importance.)

There is very little hypothesis in this system. We unite the condenser law with Ohm's law of the conduction current, on the hypothesis, which is supported by experiments with condensers and conductors, that the equation of continuity is of the kind supposed. But is assumed that the electric force is entirely due to difference of potential. As, when the current is changing in strength this is not true, there being then also the electric force of inertia, or of electromagnetic induction, this should also be taken into account in the Ohm's law equation, making a corresponding change in the characteristic equation. What difference this will make in the manner of the propagation will depend upon the relative magnitude of the electric force of inertia and of the charge, and materially upon the length of the line. The necessary change will be made in the next section. At present we may only remark that electrostatic induction is most important on long submarine cables, and that the (71) equations are those to be used for them for general purposes, as the first approximate representation of the facts of the case.

In 1854 the practicability of Atlantic cables was being discussed. The time was coming, and the man was ready. If the man had not been forthcoming, although there can be little doubt, from the irresistible nature of modern progress, that we should now have long cables worked practically as they are, yet it is nearly equally certain that the preliminary waste of money, literally sunk to the bottom of the sea, or to the bottom of the pockets of speculative inventors, would have been enormously greater than it was.

Now, as regards the accumulation difficulty. This is entirely removed in a beautifully simple manner in Maxwell's theory. The line-integral of the magnetic force round a wire measures the current in it, a fact that cannot be too often repeated, until it is impressed upon people that the electric current is a function of the magnetic field, which is in fact what we generally make observations upon, the electricity in motion through the wire being a pure hypothesis. Maxwell made this the universal definition of electric current any where. There is no difference between a current in a conductor or in a dielecteic as a function of the magnetic field, though there is great difference in the effect produced, according to the nature of the matter. All currents are closed, either in conductors alone, or in dielectrics alone, or partly in one and partly in the other. In a conductor heat is the universal result of electric current, and energy is wasted; in a dielectric, on the other hand, the energy which would be wasted were it conducting is stored temporarily, becoming the electric energy, which is recoverable. In a conductor, the time integral of the current is not a quantity of any physical significance; but in a dielectric it is a very important quantity, the electric displacement, which can only be removed by an equal reverse current. The electric displacement involves a back electric force, which will cause the displacement to subside when it is permitted by the removal of the cause that produced it. Put a condenser in circuit with a conductor and battery. The current goes right through the condenser. But it cannot continue, on account of the back force of the displacement; when this equals the impressed force of the battery, there is equilibrium. Remove the battery and leave the circuit closed. The back force of the displacement can now act, and discharges the condenser. As for the positive and negative charges, they are numerically equal to the total displacement through the condenser. They are located at the places of, and measure the amount of discontinuity of the elastic displacement, and that is all.

If we must have a fluid to assist (keep it well in the background), then this fluid must be everywhere, and be incompressible, and accumulate nowhere. I am no believer in this fluid. Its only utility is to hang facts together. But when one has obtained an accurate idea of the facts it has to hang together, it has served its purpose. A fluid has mass, and when in motion, momentum and kinetic energy. But the facts of electro-magnetism decidedly negative the idea that the electric current *per se* has momentum or energy, or any thing of that kind; these really belong to the magnetic field. It is therefore well to dispense with the fluid behind the scenes.

But when one thinks of the old fluids (of surprising vitality), and of their absurd and wholly incomprehensible behaviour, their miraculous powers of attracting and repelling one another, of combining together and of separating, and all the rest of that nonsense, one is struck with the extremely rational behaviour of the Maxwell fluid. When, further, one thinks of the greatly superior simplicity of the manner in which it hangs the facts together (it is remarkably good in advanced electrostatics, impressed forces in dielectric, &c.), one wonders why it does not take the place of the commonly used two-fluid hypothesis, merely *as* a working hypothesis, and nothing more.

Returning to the wire. It is important to remember that there are two conductors, not one only, with a dielectric between. When we put an impressed force in the wire we send current across the dielectric as well as round the conducting circuit. The dielectric current ceases as soon as the back force of the elastic displacement supplies that difference of potential which is appropriate to the distribution of impressed force (which difference of potential depends entirely on the conductivity conditions). The equation of continuity means that when the current entering a unit length of wire on one side is greater than that leaving it on the other, the excess goes across the dielectric to the outer conductor, in which there is a precisely equal variation in the current. The time integral of this dielectric current $\dot{q}$ is q, which is the total displacement outward per unit length of wire. The quantity V is the back E.M.F. of the displacement. On removing the impressed force, there is left the electric energy of the displacement, which is $\frac{1}{2}Vq$ per unit length of wire; the back forces act, discharge the dielectric, and this energy is used up as heat in the conductors.

We can now make some easy extensions of the system (71*b*). R must be the sum of the resistances of the wire and return, per unit length, thus removing the restriction that the return has no resistance. S, of course, remains the same. But V cannot be the potential of the wire, because V cannot = 0 all along the return. We may, however, call V the difference of potential (although that is not exactly true, on account of inertia, unless we agree to include a part of the E.M.F. of inertia in V). It is, however, definitely the E.M.F. of the condenser, given by $q = SV$. We need not restrict ourselves, in these first approximations, to round wires, or to symmetrically-arranged returns. The return may be a parallel wire. Of course the proper change must then be made in the value of S.

(To be continued.)

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M. LEVY'S REPORT ON THE PARIS-CREIL EXPERIMENTS.

The report which has been furnished by M. Maurice Levy upon the latest series of experiments by Marcel Deprez, and which is endorsed by thirty-eight members of the *Académie des Sciences*, we fear will have but little tendency to enhance the scientific reputation of any one concerned therein. Not a few of the statements, both of fact and of opinion, which are to be found in this document will certainly excite considerable astonishment—upon this side of the Channel, at any rate.

We apprehend that a report of this nature, issued in the name of a responsible and an important body, should at least be characterised by a conscientious endeavour to ascertain actual facts, and by scientific accuracy in the statement of the facts ascertained; and further, if under the existing circumstances it is to have any definite or lasting importance, it should certainly have contained an impartial estimate of the results of the experiments, regarded not merely as a demonstration of known principles, but as an indication of the direction in which further progress is to be attained. In all these points the report now before us falls lamentably short.

Before criticising the document in detail, it will be convenient to state what were the results which M. Deprez set himself to accomplish, and how far he succeeded in carrying out his programme. Briefly stated, it was proposed to take 200 horse-power at Creil, to transmit the energy over a line 56 kilometres in length to La Chapelle, and *to effect the distribution of power* from this point with a total loss not exceeding 50 per cent. It is evident that the interest of this programme (of course we are now speaking solely of scientific or industrial interest) centres in two points. First, in the manipulation of the current over so long a line under the very high potential which must be employed; and, secondly, in the *distribution* of the energy from the receiving station under the conditions laid down. The mere *experimental* transmission of a considerable quantity of energy over a considerable distance, noteworthy and marvellous though the experiment may be in itself, is not from the point of view of the modern electrical engineer—and especially after the verification of theory which M. Deprez has himself already amply supplied—a result of any special interest or value, save as a demonstration of established principles. It is perfectly well understood that any given power can be transmitted over any given distance with any given loss *en route*, if it is permissible to employ a sufficiently high electromotive force. And if we are allowed to build a machine containing an unlimited quantity of iron and copper the necessary difference of potential can always be attained. Since, then, M. Deprez avowedly did not aim at economy in the construction of his "modified Gramme" machine—which, in fact, cost some £2,000—we are justified in asserting that the interest of the programme is practically confined to the two points already mentioned.

The question next arises how far was this programme actually carried out? In the first place, owing to difficulties connected with the construction and insulation of the generator, the total brake-power to be transmitted was incontinently reduced one-half, so that 100 horse-power was the maximum actually dealt with. The precise efficiency of transmission obtained between the pulley of the generator and that of the receiver remains a matter of some uncertainty. It was probably, however, within 10 or 12 per cent. of the figure aimed at. But the grand problem of a *distribution* of power from a distant source with a total efficiency of 50 per cent. was not in reality so much as attempted. The so-called distribution was effected by means of a second Gramme machine which was driven as a dynamo *from the pulley* of the receiver, and the low tension current so generated was employed to operate a lathe, a hammer, a pump, and so on by means of an additional number of small motors. Now, this method may or may not have been the most appropriate means for the distribution of the energy of the high tension current, but inasmuch as the 45 or 50 per cent. efficiency which is claimed was measured *upon the pulley of the first receiver*, we are justified in stating that the original programme was not carried out, even upon the reduced scale.

Turning now to the question of the management of high potentials, it is a sincere pleasure to be able to congratulate M. Deprez on having successfully demonstrated that a potential of more than 6,000 volts may be maintained under practical conditions upon a very long and exposed cable, and may be manipulated by the men employed without any special difficulty and apparently without any special risk. It is true that M. Deprez's record is not perfectly clear in this matter. An unfortunate mishap occurred at the very time when the installation was being inspected by some of the members of the Academy—an accident which involved the destruction of two unoffending telegraph instruments at St. Denis, as well as that of the armature of the generator. But notwithstanding this mishap, now that the installation has been at work for a period of over six months without further difficulty of this character arising, M. Deprez is undoubtedly entitled to the honour of being recognised as the first to achieve the practical employment of high tension electricity upon so large a scale.

We take it that this is by far the most important result—if not, indeed, the *only* important result—of these experiments. It is therefore the more surprising that this matter should have been passed over entirely without mention in M. Levy's report. He certainly makes reference to the employment of a high electromotive force, but although his vocabulary proves to be amply supplied with expressions of admiration and astonishment, he has nothing to say in praise of this particular achievement. As a matter of fact, we are enabled to add from an authentic source the information that for purposes of experiment M. Marcel Deprez has more than once employed a tension of over 10,000 volts at the terminals of the generator, and although the receiver showed some signs of distress no other difficulty was experienced.

We may yet have some further criticisms to offer with regard to M. Deprez's method of procedure, but we return now to M. Levy's report, from which we take the following tabular statements:—

TABLE I.

—	(1)		(2)		(3)		(4)		(5)	
	Creil.	Paris.	Creil.	Paris.	Creil.	Paris	Creil.	Paris.	Creil.	Paris.
Current	6·879	6·827	7·554	7·457	8·229	8·103	9 129	8·936	9·879	9·824
Potentials at machine terminals	4688	4163	4996	4526	5366	4836	5716	5269	6004	5456
Current in field-magnets	31 07	27·65	31·84	29·31	31·07	30·42	34·4	32·07	36·3	34·29
Revolutions per minute	168	244	182	257	199	267	206	278	218	295
Work absorbed by generator in horse-power...	66·7	..	77·1	..	86·1	..	102	..	116	..
Mechanical work on pulley of receiver in h.p ..	..	27·2	..	32·8	..	38·6	..	44·8	..	52
Industrial return per cent.....	40·78		42·54		44·83		43·92		44·81	

TABLE II.

	Resistances.	ohms.
Generator	Armature	29·00
	Field-magnets	5·75
Receiver	Armature	38·15
	Field-magnets	3·82
Line	.....	97·45

Table I. gives the principal measurements which were taken, and it should be noted that the whole of these figures were obtained between the hours of 10:20 a.m. and 11:10 a.m. on one single morning. The readings cannot, therefore, have been submitted to much verification. This will to some extent account for the striking discrepancy of nearly 50 per cent. which M. Levy has himself noticed in his calculation as to the loss of power upon the line. From the figures given in the table it is easy to calculate the work apparently lost in the machines, and, deducting this from the total loss of horse-power, we ought to obtain the work expended in the line. Taking Experiment No. 5 as an example, we find in this way the figure 7·3 as the horse-power expended in the line. But

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we may also obtain an approximate estimate of this loss from the known resistance of the line and the *average* current measured at either end. We thus obtain the figure 12·7 as representing the horse-power wasted in the line. M. Levy is, however, careful to explain that his measurements only aim at "industrial," and not at "scientific" accuracy. However unsatisfactory such a discrepancy may be in itself, we are not disposed to attach any serious importance to the matter save as an illustration of the value which is to be attached to the figures supplied. M. Levy disposes of the difficulty by remarking that as the higher figure for the loss in the line is undoubtedly correct, the work expended in the machines themselves as determined by dynamometer and brake is too high by 5·4 horse-power, and it "will be fair to share this difference between the two machines." He proceeds accordingly to increase the calculated efficiency of each machine in this proportion.

But perhaps the most remarkable part of the report is that in which M. Levy deals with the question of the line and its insulation. He is of opinion that it is "*infiniment désirable et important*" to carry out a similar experiment *with an earth return*, and he expresses an earnest desire to witness the attempt. For our own part, we shall have much greater confidence in the "desirability" of this idea after M. Levy has successfully tried the experiment for himself than we have at present. In fact, it is somewhat doubtful whether there would be any "earth return" for the experimenter himself. A friend of ours even suggests that if the results of the observation are not to be entirely lost to science, it will probably be necessary for some one to repeat the expedition of the great mediæval poet of Italy. To say the least, the absence of a return wire must tend vastly to increase the chances of a catastrophe. With a return wire we are told that a distance of 0·75m. to 1m. appears sufficient to avoid "absolutely" all inductive effects upon adjacent telephone circuits. If this is an experimental result—which is not very clear—the observation is one of some value. M. Levy has also arrived at the conclusion that it is wiser to allow the overhead wire (if placed upon sufficiently high posts) to remain entirely uncovered. This is a point upon which opinions will probably be found to differ. We entirely fail, however, to see any advantage whatever in the arrangement adopted in the first instance by M. Deprez. He employed a lead-cased wire, apparently made after the pattern of the well-known Berthoud-Borel cables. An overhead lead-cased line seems to be open to several serious objections, not only would it considerably add to the cost of construction, but the loss by Foucault currents would probably be distinctly perceptible over so great a distance, the current not being absolutely continuous. In addition to this, the static charge might prove decidedly inconvenient. On this point, M. Levy's ideas are not a little singular. He says that "in wet weather, or when the insulation of the line is not perfect," the cotton and resin placed between the copper and the lead will play the part of the glass in a Leyden jar, and dangerous results may ensue. In what way the dielectric action is supposed to be increased, or to become more dangerous because of the defective insulation, we are at a loss to imagine. It is, however, for this reason that M. Levy prefers the use of a bare wire. At this point we are informed that the weight of the lead increases the sag of the wire, unless the latter "be submitted to an electric tension capable of breaking it."

Similar observations of equal value and importance are lavishly scattered over this document, but our space will only permit us to refer to one more point in detail, and here our criticisms will be directed to the work of M. Deprez more than to that of his reporter. The latter, however, declares the arrangement in question to be both "*neuf et heureux.*"

We have already referred to the somewhat complicated arrangements at the receiving station, where the armature shaft of the receiver is mechanically coupled to that of another machine from which the *distribution* of power is effected. In reality, however, there are two separate and distinct dynamos driven from the shaft of the receiver. The current from the second of these machines is employed to excite the field-magnets of the receiver itself. This arrangement is adopted because of the powerful extra current which would be generated in the field-magnet coils if they were in the line circuit, and the latter were suddenly interrupted at any point. It will, however, scarcely be considered that this arrangement affords a satisfactory or, indeed, a practical solution of the difficulty. In order to start the machines under these conditions it is necessary to employ a switch which first puts the armature and a portion of the field-magnet coils together in series with the line. The armature having commenced to move, the magnet coils are successively cut out of the main circuit, and introduced in parallel into the circuit of the exciter. This, at least, is the description of the arrangement which we find in the report; but we are inclined to think that if the machines are started with the full difference of potential there must be some additional resistance to be inserted when the current is first switched on. If so, however, this could hardly have escaped M. Levy's attention, as it would appear that the resistance coils would have to be of decidedly large dimensions. In any case it seems to us that the method must incur a very considerable risk of placing the full potential upon the armature of the machine when no counter electromotive force was being generated. In such a case, to quote from another portion of the report, "it may be that the recipient which has hitherto lasted without repairs will in turn come to require them."

A THERMO-MAGNETIC PHENOMENON.

It is well known that at a high temperature iron loses its magnetic properties. It is therefore evident that if we take an iron ring and balance it upon an axis passing through its centre, then if we can keep one half comparatively cool while the other half is maintained at a red heat, the presence of a magnetic pole at the junction of the hot and cold sections should cause a rotation of the ring.

The idea is not new, and as a laboratory experiment it has already been carried out upon a small scale. In a recent number of the *Journal de Physique*, M. Schwedoff contributes a paper on the theory of this action, pointing out that it is quite evident that the motive power is derived indirectly from the source of heat, and proceeding to inquire into the successive steps of this transformation. In order to reduce the experiment to its most simple conditions, he considers first the case of a ball of iron suspended by a thread or wire in the neighbourhood, say, of the flame of a Bunsen burner. A magnet is placed in such a position that its attraction draws the ball into the centre of the flame. As it grows hot the ball gradually loses its magnetism, and moves slowly away from the magnet and out of the flame. Here it begins to cool, and presently it slowly returns towards the magnetic pole, and this action may be repeated indefinitely. M. Schwedoff then proposes the use of the term *elastic force* in somewhat the same sense as the old phrase *coercitive force*, only he distinguishes two actions tending to limit the value of the coefficient of magnetisation; one the inherent resistance of the material to any change in the relative position of its molecules, the other to the increase of polar repulsion between the molecules when the magnetic action tends to give them the same orientation. It is to the former resistant effect that he alone applies the term "magnetic elasticity." Returning to the suspended ball, he supposes that in the neighbourhood of a red heat the "coefficient of the magnetic elasticity" increases directly with the temperature. Work is done upon the ball in the first instance in order to direct its molecules into magnetic orientation, and this work is done solely at the expense of magnetic potential. The action of the flame then tends to restore the molecules to their initial condition; this requires the expenditure of energy, which appears in the shape of an increase of the potential of the magnet upon the ball. In order to furnish anything like a complete theory it would, of course, be necessary to take account of the electro-magnetic reactions due to Foucault currents in the ball.

But the above simple explanation is sufficient to enable one to trace the order in which the transformation of energy takes place.

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AN ELECTRICAL THEORY OF THE UNIVERSE.

If Germany is the home of speculation there is a gentleman at Dunkirk, N.Y., who was evidently born in the wrong place. Dr. HENRY RAYMOND ROGERS bears a name which is at least half Anglo-Saxon, and his language betrays that he is wholly American; yet he has lately been delivering himself in a speculative way befitting only a German professor at the most German of German Universities. His lecture, which has been forwarded to us in pamphlet form by the author, and for which we greatly thank him, was originally read before a Society of History and Natural Science. This society is mysteriously designated "The Chautauqua." Whether the title has any influence on the science which prevails there, or whether it is merely descriptive, we know not; all we say is that the "New Philosophy of the Sun," as expounded by Dr. ROGERS, is very much Chautauqua. By which we do not mean anything disparaging of the author, much less of his philosophy; far from it. All we intend to convey is that, like Chautauqua, it is hard to swallow straight off; and wants more explanation before we even understand it.

We advise our readers to obtain Dr. ROGERS' pamphlet for themselves; it is certainly entertaining, and is worked out with a boldness, vigour, and originality which more than compensate for its literary and logical shortcomings. The author does not stick at trifles, and his manner of overcoming objections to the new philosophy—on the few occasions when he condescends to see them—is of the hop-skip-and-a-jump order. But this is always the way with innovators; and we cannot expect even a new philosophy to be ushered into the world with a perfectly philosophical spirit. For this reason we propose not to criticise it, but simply to give a brief outline of its main features. Whether Dr. ROGERS be right or wrong he will not be wanting in critics; and if he should prove some day to have been in the right, we would like to be among those who received him with an open mind. Journalistic instincts for the moment get the better of our scientific prepossessions.

On the concluding page of his pamphlet Dr. ROGERS quotes a prediction of FARADAY'S that a "glorious discovery in natural knowledge," explaining the purpose and uses of the earth's magnetism, was looming in the near future. Dr. ROGERS claims to have made this discovery. Nay, more, he has discovered that the Sun, the Earth, and all the planets are magnetic, and that the phenomena of their orbital and axial movements are accounted for by their magnetic relations towards each other; moreover, that sunlight and sunheat are not what they seem to us to be, but are magnetic, or, what is really the same thing, electric emanations from the sun converted into light and heat by the earth's atmosphere. Sun spots are explained away as magnetic disturbances which temporarily interfere with the current lines between sun and earth, but have no substantial existence as spots on the surface of the great luminary. Similarly the Corona, the Zodiacal light, and other puzzling solar peculiarities, are attributed to atmospheric and local causes. Lastly, gravity is in reality electrical attraction, and, according to our author, Sir ISAAC NEWTON himself had some inkling of this fact; whilst in recent times FARADAY was quite certain about it.

There is some ambiguity as to the part played by the Moon in this philosophy; but the author leaves it so, and so will we. About the Sun he is very explicit. It is not bright, and it is not hot. At great elevations it is pale and cold like the Moon; and is therefore only a light and heat giver by reason of the atmosphere, whose resistance converts the solar electrical influences into a sort of terrestrial electric light. The magnetism of the heavenly bodies, it is needless to say, becomes electricity with the motion of those bodies in relation to one another; their magnetism makes them attract and repel each other within circumscribed orbits, and the movements so maintained give rise to their electrical currents. The Sun is inhabitable; and the earth is as bright to the inhabitants of the Sun, as Venus, Mars, and Jupiter appear to be to us. What we take to be heat rays are really electrical rays, as is proved by the identity of effect on passing the sun's rays and electrical rays through a block of ice. From the assumption that a "vacuum is the most perfect condition for electrical transmission," the analogy is drawn that the region beyond the earth's atmosphere offers no obstacle to the instantaneous passage of electricity between sun and earth.

Having set the balls a rolling our author follows them throughout their wondrous courses. Starting from FARADAY'S axiom that the rotation of all bodies opposite to magnets induces circulating electric currents, the inference is drawn that the stellar worlds whirling in space evolve between them electrical currents in great cosmical circuits; and that the sun and earth, revolving on their axes and in their orbits, constitute a vast terra-solar electrical machine, to the action of which is due the currents which incessantly come from the sun to the earth. In this way the sun and all the stars have, so to speak, been put in harness for the performance of the work of

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the universe. Thick bars of hardened steel have been cut through by a disc of thin sheet iron revolving with great velocity, but never touching the steel. The atoms of metal held by the electrical force of mere cohesion become loosed by the action of a stronger electrical force due to the revolving disc. Sparks flew and drops of liquid steel fell freely, but they *were not hot*. Our readers will draw the proper inference without further help from us. It is some satisfaction to know that when this round Globe shall be dissolved—possibly through human meddling with the electrical balance—the resulting sparks and things will *not* be hot.

We have only space to add a quotation or two by way of further elucidating this new solar theory. Of the identity of gravity and electricity we are told that "the sun and earth being magnets excited into activity by their motions become constituents in an electrical circuit, and thoroughly vitalised with the power we call gravitation. Thus the relation between electricity and gravity is simply that of *cause* and *effect*." In a section devoted to sunheat and sunlight, the author remarks: "If our sun and the many millions of star-suns were incandescent, and disseminated heat and light in all directions, all space would be heated and lighted. There would be neither cold nor night on this earth of ours." A better philosophy is needed; and here it is, summed up in a sentence: "The sun's current, like the current from an electric dynamo, is invisible, gives no manifestation, passes through space like electricity through wires; without being itself hot it develops heat; without being itself luminous it develops light, and endues with attractive powers that which it pervades."

BELLING THE CAT.

It will be seen from an account in another column that a meeting of a somewhat unusual character has been held at the Cannon-street Hotel. This assembly, which was attended by an influential gathering of reporters, was convened by a firm who have interested themselves in the question of incandescent lamp patents, and have even entered an action against one of the larger makers for "intimidating their customers and interfering with their trade." The real purpose for which the meeting appears to have been summoned was that they might be invited to form a committee charged with the duty of assisting the promoters in the conduct of this action. The names of the gentlemen who were found to be willing to accept this task will be found in our report, but, as may readily be supposed, the names of those who are most interested in the question of lamp patents are conspicuous by their absence.

The proceedings were commenced by a very charming little address, delivered in the popular lecture style by Mr. Arthur Shippey himself, in which, after having expounded his views upon the future of electricity ("yet in its infancy" and so on), the audience was treated to a *réchauffé* of the history of incandescent lamps. It is only fair, however, to add that a certain number of the facts adduced really do appear to have been hitherto unknown, and they may even yet prove to have considerable practical importance in the history of this subject.

The outcome of Mr. Shippey's researches will be seen to have led him to the conviction that there are only four absolutely original and valuable patents covering a complete incandescent lamp. Of these Lane-Fox, Edison, and Bernstein will, we are sure, feel infinitely obliged to Mr. Shippey for putting their work upon a level with his own. If the whole thing were not so transparently ludicrous, we should deem it our duty to enter a most emphatic protest against this latest development of the great modern art of advertising.

CORRESPONDENCE.

ABSOLUTE NEGATIVE CHARGE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The writer of the letter entitled "Absolute Negative Charge" in your journal dated the 6th inst. invites a discussion on that theory. Hardly expecting that he will be overburdened with letters in support of the theory, I take the opportunity of asking him if he will kindly explain the relation between the word "static," used in connection with electricity, and the theory he expounds in his letter, at least, in the last paragraph?

In that paragraph he refers to the "electrostatic circuit" (would not "electro-inductive" convey the meaning better?) "which is absolutely analogous to the conductive circuit." I translate the sentence as analogous, not only in forming a complete circuit, but also in transmitting electricity.

This refers me to the second paragraph of the letter.

The cracks and squeaks which proceed from a rope when under strain seem to imply that there is considerable yielding going on among its molecules while under this strain. Does not much the same kind of action take place in an inductive circuit? Is not electricity being transmitted, in however small quantities, along the inductive circuit? If not, how is it that a dielectric, or an insulated conductor, can never keep its charge? Where does the charge go to, and how does it go there? It certainly combines with its opposite charge by passing along the lines of inductive resistance, which separates it from the opposite charge (the canal explained in the letter referred to). If this is true, why call it static or stationary electricity? Is it not advisable in science to use words which carry the ideas as much as possible exactly to what is meant without its being necessary to explain that a certain word does not mean what it generally means? Why continue to use old and obsolete terms when the theories which they referred to are dead and buried, and making subjects that are already sufficiently difficult doubly difficult to understand?

Why this application of old patches to new garments.—Yours, &c.,

LIONEL E. CAINE.

Villa Real, Algarve, August 13th, 1886.

THE LALANDE BATTERY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Your correspondent, "Battery," in his letter of last week on the subject of the Lalande battery, appears to have some misconception as regards "available energy." Referring to six Lalande cells charging accumulators he says:—"Taking the E.M.F. of six cells in series as four volts, we have $4 - 2{\cdot}5 = 1{\cdot}5$; then multiplying this by the ampere current we only obtain as available energy something like 9,000 watts." He surely must see that this 9,000 watts (which should be watt-hours by the bye) is *loss*, and not available energy. He further states that this 9,000 watt-hours is, "of course, the measurement in the charging circuit," and that in the discharging a lamp circuit it must be 5 per cent. less. He, however, finishes up by bringing his final calculation to 12 per cent. more, namely, 11,400 watt-hours. The last part of his calculation I admit as being correct, and in accordance with my figures as published in your issue of 13th inst, the only difference being that I allow for accumulators from the fact that there is usually *over* 6,000 ampere-hours for 120lbs. of zinc consumed. This is the case when the primary battery is worked in conjunction with accumulators The 4·2lbs. of zinc per horse-power refers to when the primary battery is worked alone, as is the case in many instances at the present time, both for light and power. The reason for using the combination (and consequent extra consumption of zinc per horse-power) is the advantage gained in space occupied and labour of re-charging. If it is not encroaching too much on your space, I should like, whilst on the subject, to make a few remarks with regard to estimating the cost of obtaining electric light from batteries. I notice that in almost all the calculations on the subject the bare cost of materials required and their equi-

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valent in watt-hours is taken into consideration. This no doubt would be all very well if the public would undertake the re-charging of their own batteries; but such is by no means the case. Having had considerable experience in the practical working of batteries on a large scale for lighting purposes, I have no hesitation in asserting that for any system of primary batteries to be largely adopted the user must have little or nothing to do with the re-charging of the cells. This must be entirely undertaken by those supplying the batteries. Now, the cost in labour, carts, horses, &c, to keep such installations going is considerable. The more complicated the battery the greater the cost. One of the first points to be aimed at is simplicity in construction and manipulation of the cells. Then, again, a great deal depends upon how the various installations are distributed, how many one cart and horse can deal with in a day, the nature of the liquid or liquids to be removed. These and a great many other important matters over and above the actual cost of materials have to be taken into account when calculating the cost of maintenance, &c. It practically comes to this. With a given battery how many watts-hours can a cart and horse and two men distribute amongst installations of a given size per diem, and at what cost? Apologising for the length of this letter,—Yours, &c.,

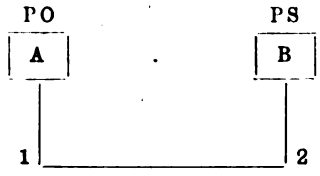
STANLEY CURRIE.

75, Jermyn-street, St. James's, August 26.

UNDERGROUND INSULATION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I make a drawing sufficient for all practicable purposes to illustrate what I am about to state.



The distance between the President's office, Penna-road (PO) and passenger station (PS) is 9,500ft., and underground cable insulated with oil extends from the cellar of each building. We mark these cellars as 1 and 2. There are telegraph and telephone wires working in this cable, but from cellar of 1 and 2 to the switch-boards A and B lead-covered cables are used with a solid substance for insulation.

If we put a telephone at the junction of the liquid with the hard insulation in the cellar at 1 upon one of the conductors open at B—the switch-board, which is 65ft. above the cellar—we hear the Morse click or signals; but if we open the same conductor at 2 cellar we hear nothing, the telephone being connected to earth in the cellar. Similarly, if we put the telephone on a conductor at 2, connected to earth, and open the circuit at 1, we hear nothing; but if we open at A we hear the same Morse signals; in other words, if the wires are insulated with hard matter for 60ft. we get inductive disturbance, but if confined entirely to oil 9,500ft. we hear nothing, there is no inductive disturbance.

If at the switch-boards we put on telephones, each connected to the conductor and the earth with telephones of equal resistance, we get double the disturbance with circuit open at the farther end that we do if the circuit is closed in the usual manner of working, as all the disturbance passes through the telephone to the earth if the farther end is open; but if both ends are connected to earth then it is divided, or very materially lessened; but if the farther end of the circuit is connected directly to earth and the telephone taken out of the circuit, then the disturbing effects are less than when the telephone at the farther end is in the circuit. They (the disturbances) go to the earth through the channel of least resistance.

Now, measuring these underground wires for electrostatic capacity with all the other spare conductors connected to earth, they show about four-tenths of a microfarad per mile, while those in the lead-covered cable show less than two-tenths per mile.

I have given these facts, which corroborate the others that have heretofore been published indicating that inductive disturbance in telephones is more a question of acoustics than of electrostatic capacity of the insulator.—Yours, &c.,

Philadelphia, Aug. 13, 1886. H. C. FREMPT.

EARTH CURRENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of August 6th, a diagram is given showing the great earth current storm on the cable between Shanghai and Nagasaki on March 30th last, the storm commencing at 4:20 p.m. and disappearing at 11 p.m., Shanghai time. In *The Electrician* of April 2nd, p. 404, is an account of the same storm as observed in London, Bombay, Madras, and Singapore. On the evening of March 30th I noticed from my house at Kingstown, co. Dublin, a splendid auroral display. Between 9:30 and 10 p.m. the maximum brilliancy occurred. The same aurora was seen in Prussia; but the only British notice of this unusually fine aurora that I can find is in a paragraph in *Nature* for April 8, where Mr. G. H. Kinahan gives an account of an aurora seen by him in Donegal on March 30th, between 8 and 9 p.m. The appearance of the aurora as seen by both Mr. Kinahan and myself was different from the type usually observed in this country, consisting of bright streamers, and columns of light rolling rapidly from the northerly horizon up to near the zenith.

My object in writing is to draw attention to this remarkable and widespread earth current storm, and to point out that, as might be expected, it was coincident with the occurrence of a brilliant auroral display. I should be glad if you would allow me also to ask your readers for any other information they may be able to give in connection with this great electric disturbance.—Yours, &c., W. F. BARRETT.

Royal College of Science, Dublin, August 21.

LITERATURE.

Ueber die Darstellung der Farbstoffe so wie über deren gleichzeitige Bildung und Fixation auf den Fasern mit Hilfe der Electrolyse.*

This pamphlet, of 140 pages, is a reprint of articles which originally appeared in an Austrian paper, "Oesterreich's Wollen und Leinen-Industrie." As such it appeals chiefly to a class of readers who are interested in textile fabrics, and who have some knowledge of dyeing processes, and is intended to give them a popular account of investigations in which the author has been engaged for the last eleven or twelve years. The first three chapters are introductory, and contain a short sketch of the history of electricity and electro-chemistry, and a general description and explanation of electrolytic action, together with an acknowledgment of the author's indebtedness to Prof. Schoenbein, who was formerly his teacher and afterwards his colleague, and whose important investigations into the constitution and properties of ozone led the author to take up the line of research, the results of which are described in the present work.

In chapter IV. the author describes his process of preparing aniline black by the electrolytic decomposition of the sulphate or chloride of aniline by means of the current from a dynamo or a strong battery. The electrodes, consisting of platinum or carbon plates, were placed in separate vessels communicating by means of a bundle of cotton or linen threads, or a strip of filter-paper, enclosed in a tube of parchment to check evaporation; or a capillary siphon tube, dipping into both the vessels.

When the current is allowed to pass, a precipitate begins to form in the vessel containing the positive electrode, and the solution in this vessel soon begins to show a green colouration, passing gradually through violet to a dark indigo blue, and which ultimately becomes nearly black.

This reaction is so delicate, and so characteristic, that it may be advantageously employed to detect traces of aniline salts in solution.

By increasing the strength of the solution other colours can

* On dyes, and their simultaneous production, and fixing in fabrics by means of electrolysis. By FRIEDRICH GOPPELSROEDER.

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be obtained, *e.g.*, yellow, orange red, and red. The bundles of threads used to connect the two vessels were also found to become coloured, and among the colours observed were violet, red, salmon, green, grey, and brown.

The negative electrode also became covered with a black or yellowish brown precipitate, and the solution containing it sometimes remained colourless—as also occurred in some cases with the positive electrode—and sometimes showed a brown, yellow, or red colouration.

The colours are due to the formation of a mixture of various colouring matters, but the author succeeded in separating the principal product at the positive pole, aniline black, in the form of a perfectly black powder, which can be transformed into various other colour compounds by methods which he describes. Chapter V. contains an account of some of the more important chemical reactions of aniline black, and of methods of preparing dyeing solutions of various colours from it. Chapter VI. is devoted to the consideration of colouring matters obtained by the electrolysis of various aromatic substances, such as compounds of toluidine, of methyl—and ethyl-aniline, of diphenylamine, &c. Chapter VII. treats of the separation, by capillary action, of different colouring matters mixed in the same solution. The most simple and convenient method is to dip the ends of slips of white filter-paper into the dye, when, if the solution contains a mixture of several colouring matters, a series of well-marked horizontal bands of colour will be produced on the paper. The author points out that the adulteration of wine with colouring matters may be detected in this way, and he has also employed the method with success to determine the sources of contamination of water, and of the soil, in the immediate neighbourhood of several chemical factories. In Chapter VIII. the author gives an account of results obtained by the electrolysis of anthraquinone, and describes a method of converting crude indigo into indigo-white by means of electrolysis. The crude indigo is kept in suspension by continual stirring in a hot solution of alkali, such as caustic potash, during the process, and the solution of indigo white obtained in this manner can be used without further preparation in the dyeing vat. After immersion in the vat the fabrics are exposed to the air, as in the ordinary process, in order to reconnect the indigo white into blue indigo by the absorption of oxygen. The author finds that the transformation of indigo blue into indigo white by means of electrolysis takes place even in a cool solution, but very imperfectly. The best results are obtained by raising the temperature of the solution until the evolution of hydrogen practically ceases, as all the hydrogen set free is then employed in effecting the transformation instead of being wasted. The current must not be allowed to flow for too long a time, as in that case, even in a cool solution, the indigo white undergoes further changes, which weaken the solution.

In Chapter IX. a description is given of the author's method of effecting, by means of electrolysis, the transformation of crude indigo into indigo white, and simultaneously fixing it in the fabric to be dyed. A series of experiments are described in which the fabric was placed between the two electrodes and in contact with each of them, and it was found that the sides of the fabric in contact with the positive and negative electrodes respectively, became differently coloured, even when the two electrodes were of the same metal, and a number of different shades of blue were obtained by varying the metal of which the electrodes were formed, and by using, in some of the experiments, different metals for the positive and negative electrode. Methods are also described of simultaneously producing and fixing upon various animal and vegetable fabrics, other dyes, such as persulphocyanogen or canarine, and dyes belonging to the aromatic series, including aniline black. Some experiments are described, in which the aniline black was produced in the form of patterns or written characters. A metal plate, forming the negative electrode, was supported on a sheet of caoutchouc and covered by a piece of stuff thoroughly soaked either in a solution of an aniline salt or dilute sulphuric acid, and on this was placed the fabric destined to receive the pattern, having been previously saturated with the aniline solution. The pattern was produced by means of a gold, or platinum tipped metallic pencil which formed the positive electrode. The author has made some attempts to produce these patterns mechanically by means of an engraved plate or roller forming one of the electrodes, and having its uncut portion covered with non-conducting varnish, the other electrode consisting of a plain plate or roller, and the fabric, previously saturated with a thickened aniline solution, being placed between them, but he has not yet succeeded in obtaining satisfactory results.

The author then goes on to describe methods of bleaching by electrolysis, fabrics already dyed, and describes the results obtained in a series of experiments upon fabrics which had been dyed with indigo and with Turkey red respectively. The rest of this chapter is devoted to the consideration of the electrolytic transformation of cellulose into oxycellulose, and of electrolytic methods of producing new shades of colour in fabrics which have been previously dyed. In the two following chapters the author describes an electrolytic method of fixing *mordants* consisting of metallic oxides, on fabrics which are to be dyed, and gives a preliminary account of some researches, which are not yet completed, on the direct fixing of metallic particles in fabrics by means of the electrolysis of their salts.

Chapter XII., which concludes the work, contains some notes on the electrolytic transformation of bases of the aniline series into bases of the leucol, or quinoline series, and on the electrolysis of some natural dyes; some general remarks on the chemical action of frictional electricity, with references to memoirs on the subject, and a short historical sketch of chemical telegraphs.

The work is well worthy the attention of all who are interested in dyeing processes, and it is to be hoped that the publication of these interesting and suggestive researches in an easily accessible form may induce practical workers in this country to devote their attention to the further investigation of the electrolysis of colouring matters, and to the application of results, hitherto tested only in the laboratory, to the further improvement and development of the dyeing industries.

WIND POWER FOR ELECTRIC LIGHTING.

We are not aware that any attempt has hitherto been made in this country to utilise the windmill as a source of power for charging accumulators. It seems not unlikely, however, that under favourable conditions, and with properly devised machinery and apparatus the attempt might be made with success. The subject has recently attracted some attention in America, and a discussion has taken place in the columns of the *Electrical Review* of New York. It is stated that prolonged experience has shown that in that country the average velocity and duration of the wind currents may be relied on to give results equivalent to eight hours' work *per diem* at a velocity of sixteen miles per hour. The following table shows the power produced, which, of course, varies with the size of the wheel employed :—

TABLE SHOWING CAPACITY OF WINDMILLS.

Designation of mill.	Velocity of wind in miles per hour.	Revolutions of wheel.	Gallons of water raised per min. to an elevation of 100ft.	Equivalent actual useful h.-p. developed.	Average No. of hours per day during which this result will be obtained.
8½ft. wheel	16	70 to 75	1·58	0·04	8
10 ,,	16	60 to 65	4·750	0·12	8
12 ,,	16	55 to 60	8·485	0·21	8
14 ,,	16	50 to 55	11·246	0·28	8
16 ,,	16	45 to 50	16·150	0·41	8
18 ,,	16	40 to 45	24·421	0·61	8
20 ,,	16	35 to 40	31·248	0·78	8
25 ,,	16	30 to 35	49·725	1·34	8

Windmills can now be constructed which will revolve at a given speed within certain wide limits of wind-pressure, and with a constancy amply sufficient for the purpose of charging accumulators. This result is attained in part by an arrange-

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ment which automatically varies the sail surface as the pressure of the wind changes. The type of mill referred to in the above table can be made to run at the same speed when the velocity of the wind has fallen as low as six miles per hour—a figure which represents a very gentle breeze. If the sail area remains constant the power given out varies inversely as the cube of the velocity of the wind. The cost per horse-power per hour for the larger sizes is given as 2½ cents. It will, however, be observed from the figures that the system is only applicable upon a comparatively small scale.

ELECTRICAL THEORIES.

BY PROF. J. J. THOMSON, M.A., F.R.S.

(*Concluded from page 264.*)

The following values of u, v, w satisfy this condition :—

$$u = \frac{1}{\mu}\left\{\frac{d^2}{dy\,dt}(FG) - \frac{d^2}{dz\,dt}(HF)\right\},$$

$$v = \frac{1}{\mu}\left\{\frac{d^2}{dz\,dt}(GH) - \frac{d^2}{dx\,dt}(FG)\right\},$$

$$w = \frac{1}{\mu}\left\{\frac{d^2}{dx\,dt}(HF) - \frac{d^2}{dy\,dt}(GH)\right\},$$

where μ is the magnetic permeability and F, G, H are the components of the vector potential, or if ψ be the electrostatic potential

$$u = \frac{d}{dy}\left\{\frac{d\psi}{dz}H\right\} - \frac{d}{dz}\left\{\frac{d\psi}{dy}G\right\},$$

$$v = \frac{d}{dz}\left\{\frac{d\psi}{dx}F\right\} - \frac{d}{dx}\left\{\frac{d\psi}{dz}H\right\},$$

$$w = \frac{d}{dx}\left\{\frac{d\psi}{dy}G\right\} - \frac{d}{dy}\left\{\frac{d\psi}{dx}F\right\},$$

If the values of u, v, w which satisfy these conditions be denoted by the (u_1, v_1, w_1), (u_2, v_2, w_2) . . . then the flow across any element of surface might have for its x component

$$\frac{1}{4\mu}(R'\beta - Q'\gamma) + \lambda_1 u_1 + \lambda_2 u_2 + \lambda_3 u_3 + \ldots$$

where λ_1, λ_2, λ_3 are arbitrary constants, thus we see that the components of the flow of energy, instead of being uniquely determined by this process are really left quite indeterminate by it. Though this is so, it is very instructive to follow Prof. Poynting's description of the way in which the energy flows in some special cases; we shall select a very simple one, the case of a current flowing along a straight wire. Here the lines of electromotive force are straight lines parallel to the wire, the lines of magnetic force are circles with their centres on the wire, and their planes at right angles to it. Then, since according to the view expressed in the paper, the energy moves at right angles both to the electric and magnetic forces, it must in this case move radially inwards to the wire where it is converted into heat. The energy, instead of being supposed to be transmitted through the wire, is regarded as transmitted by the dielectric; and though we may not regard the exact law of flow of the energy as established, still it is very important that this view should be brought into prominence. Another important point brought prominently forward in this paper is the view that magnetic force is always the sign of transference of energy, according to Prof. Poynting; indeed, there must be transference of energy from one part of the field to another to give rise to magnetic force. Thus, according to his view, no magnetic force would be exerted by the discharge of a leaky condenser, because in this case he considers the energy to be confined to the space between the plates of the condenser and to be converted into heat where it stands. If the plates were connected by a metallic wire, the energy could flow out and be converted into heat in the wire and this motion of energy would give rise to magnetic forces, so that magnetic forces would be produced by the discharge of a condenser in this way, but not by leakage. In this case the theory differs from Maxwell's, as according to that theory the alteration in the electromotive force would produce magnetic forces in either case.

In Prof. Poynting's second paper, which we have already mentioned, the fundamental principles of electrodynamics are described as the results of the motion of the tubes of electromotive and magnetic force. Maxwell develops electrodynamics from the principles :—

1st. That the total electromotive force round any closed curve is equal to the rate of decrease of the total magnetic induction through the curve.

2nd. The line integral of the magnetic force round any closed curve is equal to 4π times the current through the curve.

Prof. Poynting restates these principles in the following way :—

"1. Whenever electromotive force is produced by change in the magnetic field, or by motion of matter through the field, the E.M.F. per unit length is equal to the number of tubes of magnetic induction cutting or cut by the unit length per second, the E.M.F. tending to produce induction in the direction in which a righthanded screw would move if turned round from the direction of motion relatively to the tubes towards the direction of the magnetic induction."

The second principle he states in the following way :—

"Whenever magnetomotive force is produced by change in the electric field, or by motion of matter through the field, the magnetomotive force per unit length is equal to 4π times the number of tubes of electric induction cutting or cut by unit length per second, the magnetomotive force tending to produce induction in the direction in which a righthanded screw would move if turned round from the direction of the electic induction towards the direction of motion of the unit length relatively to the tubes of induction."

By magnetomotive force is meant the line integral of the magnetomotive force round a tube of induction. This statement includes the more special one that the line integral of the magnetic force round any closed curve is equal to 4π times the number of tubes passing in or out through the curve per second.

The development of these principles leads to equations which are practically the same as those obtained by Maxwell, the chief difference being that the quantity corresponding to Maxwell's J is no longer arbitrary or rather redundant.

Prof. Poynting also introduces into his equations the time integrals of the components of the magnetic force as fundamental quantities, and regards the components of the magnetic as the differential coefficients of these quantities with regard to the time. This method of representing magnetic force was also used by Prof. Fitzgerald in his paper on "The Electromagnetic Theory of the Reflection and Refraction of Light."* It has the advantage of calling attention to the dynamic character of magnetic phenomena. In Prof. Poynting's paper some of the applications of his method of regarding electrical phenomena are worked out with great detail for some of the simpler cases.

APPENDIX II.—*On the Stress in the Dielectric.*

In the preceding report we have had so frequently to refer to the action of the dielectric that it may be convenient to give a very brief account of the work which has been done on the stresses which are supposed to exist in it. We shall confine ourselves to the work which has been done on the stresses in the electrostatic field; those existing in the electromagnetic field are of a similar nature, so that any remark applying to one will also apply to the other. The idea of explaining the forces in the electrostatic field by means of stresses in the dielectric seems to be due to Faraday, who describes† the stress in the medium by saying that the lines of force tend to contract and also to repel one another. The magnitude and distribution of this stress was investigated by Maxwell;‡ he found that in a medium whose specific inductive capacity was K, and at a point where the electromotive force is R, a tension equal to $K R^2/8\pi$ per unit area along the lines of force combined with a presssure of the same amount at right angles to these, would produce the effects observed in the electrostatic field—that is,

* *Phil. Trans.*, 1880, Part. II.

† "Experimental Researches," Section 1297.

‡ "Electricity and Magnetism," second edition, p. 149.

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at a point in the dielectric, the resultant of these stresses would be a force whose components, parallel to the axes of x, y, z, are eX, eY, eZ respectively, e being the charge of electricity at the point, and X, Y, Z the components of the electromotive force. It may be observed that this system of stress could not be produced by the strain in an elastic solid at rest. This points to the kinetic origin of electrostatic phenomena.

These stresses are in equilibrium at a point in a dielectric where there is no free electricity. At the junction of two media, whose specific inductive capacities are K_1 and K_2, and in which the electromotive forces are R_1 and R_2, and whose interface is perpendicular to the lines of forces, the stresses are not in equilibrium, but there is an unbalanced stress $(K_1 R_1^2 - K_2 R_2^2)/8\pi$ which will tend to make the boundary move towards the medium whose specific inductive capacity is K_1; if these dielectrics are liquids, their interface may become curved so that the forces due to surface tension balance this stress.

Quincke,* who has experimentally investigated the effects of electrification on various dielectrics, such, for example, as the effects on the glass of a Leyden jar, has found that the effects on different bodies are very different; he finds, for example, that though the effect of the electrification on the dielectric of the Leyden jar is generally to produce an expansion, yet in some substances, such as the fatty oils, contraction takes place.† This diversity in the effects of electrification on different dielectrics shows that the distribution of stress cannot be so simple as was supposed by Maxwell. It also shows that there must be forces in the electric field which are not recognised either by Maxwell's theory or the theory of action at a distance. More general theories have been given in order to meet this difficulty.

Von Helmholtz‡ has supposed that a change in the density of a dielectric might alter its specific inductive capacity, and he has investigated the consequences of this supposition. Korteweg and Lorberg§ have investigated the more general case, when the specific inductive capacity of a strained dielectric is supposed to be a function of the strains. Korteweg supposes that if the body suffers dilatation e along the lines of force, and dilatations f and g at right angles to them, then the specific inductive capacity $= K - \alpha e - \beta (f+g)$. Helmholtz assumed that $\alpha = \beta$. The presence of strain in a dielectric must influence the specific inductive capacity, for Quincke has shown that the various coefficients of elasticity are altered under the influence of electricity. Lorberg, l.c., has found the distribution of stress in the medium when the specific inductive capacity alters in this way. He finds that there is a tension along the line of force equal to

$$\left(\frac{K}{8\pi} + \frac{\alpha}{2}\right) R^2$$

and a pressure at right angles to them equal to

$$\left(\frac{K}{8\pi} - \frac{\beta}{2}\right) R^2$$

The force in the medium parallel to the axis of x

$$= -\rho \frac{d\phi}{dx} + A$$

where

$$A = -\frac{R^2}{4\pi}\frac{dK}{dx} + \frac{d}{dx}(\beta R^2) + \frac{d}{dx}(\alpha - \beta)\frac{d\phi^2}{dx} + \frac{d}{dy}(\alpha - \beta)\frac{d\phi}{dx}\frac{d\phi}{dy} + \frac{d}{dz}(\alpha - \beta)\frac{d\phi}{dx}\frac{d\phi}{dz}$$

Where ϕ is the potential, and ρ the volume density of the free electricity. The part A of this force exists even when there is no free electricity at the place under consideration; if the dielectric were a fluid, these terms would indicate forces tending to move the fluid when placed in a variable electric field; this motion, however, seems not to have been observed. The supposition made by Korteweg and Lorberg is not the most general one that could be made; we might assume that the specific inductive capacity of the strained body became different in different directions, so that the body would behave like a crystal. Dr. Kerr's experiments on the double refraction in liquids placed between the poles of a powerful electrical machines seem to point to this conclusion.

Kirchhoff* has made similar assumptions to those of Korteweg and Lorberg on the effect of strain on the specific inductive capacity, and has arrived at similar equations; in the second paper he applies these equations to some cases which Quincke investigated experimentally.

* *Wied. Ann.*, X., pp. 161, 374, 513; *Ibid.*, IX., p. 105; *Phil. Mag.*, Vol. X., p. 30. (1880.)

† The fatty oils are also an exception to the rule that the index of refraction equals the square root of the specific inductive capacity.

‡ Von Helmholtz, *Wied. Ann.*, XIII. p. 385; *Wissenschaftl. Abh.* Vol. I. p. 298.

§ Korteweg, *Wied. Ann.* IX. p. 48; Lorberg, *Wied Ann.* XXI. p. 300.

ON ELECTROLYSIS.†

BY PROF. OLIVER J. LODGE, D.SC.

(Continued from page 308.)

The tests of electrolytic conduction are these four:—1. Visible decomposition. 2. Polarisation. 3. Non-agreement with Volta's series law. 4. Transparency.

We may thus pretty safely distinguish electrolytes from metals, but to certainly distinguish electrolytes from dielectrics is not always easy. True, a dielectric does not conduct, but it may break down. How to distinguish an electrolyte from a *weak* dielectric, as, for instance, rare air, is not easy. An initial E.M.F. is needed to commence disruptive discharge, but that may be easily confused with electrolytic polarisation of electrodes; indeed, some facts suggest that there is a considerable surface or boundary resistance which opposes the passage of electricity from metal into rare air, and may altogether stop it when very small terminals are used.

Second Meaning of I.—Now pass to the second aspect of the question. What is an electrolyte, viz. (*b*)? Is a particular substance the electrolyte when mixed with other matter? If a voltameter had a glass partition with a hole in it, no supporter of the view that glass was an electrolyte would contend that the glass conducted some of the current. Similarly with a water partition, or with any water existing in *a mass* in any part of the vessel. Non-conductivity or bad conductivity has thus everything to say to this question, What is *the* electrolyte? But then, in a solution of acid or salt water, it is not merely mixed with the substance, it is combined with it; and it is very possible that water in this state may conduct readily enough. Information on this head, sure and definite as it seems to me, is given by the simple fact that pure H_2O and pure liquid HCl both almost insulate when separate, but conduct well enough when mixed.

There are then four hypotheses concerning the apportionment of the current among the substances in a salt solution:—1. That the salt alone conducts; 2. That the water alone conducts; 3. That the salt and the water share the conduction between them; 4. That neither salt nor water exist, but that a hydrate is formed, and that this conducts and is decomposed as a whole.

To decide whether, when substances are mixed, both conduct the current, Hittorf mixed KCl and KI in various proportions, and concluded that the current always travelled through both sorts. Buff has made many similar experiments, and agrees. Gore has deposited brass from a cyanide solution of copper and zinc. True the combined resistance is not the semi-harmonic mean of the separate resistances; bnt there is no earthly reason why it should be. It is a mere superstition to expect such a result. Even if the substances were really mixed and not combined it would not be so; unless there were a boundary surface between the media made wholly of stream lines, *i.e.*, a surface across which no electricity flowed.‡

Another mode of discriminating between the hypothesis is to use intense currents,§ for with intense currents you are more likely to get off the real ions. Secondary actions are hurried, and cannot go on properly. With intense currents the ions are very apt to come off in a very self-combined and energetic state—as ozone instead of oxygen, &c., and an extra polarisation force accounts for this extra energy; but they do not so easily combine with other matter in the solution.

Now Magnus showed that from a solution of $CuSO_4$ weak currents deposited copper only, while strong currents liberated hydrogen as well. In fact, the observation is now a commonplace; but it is much easier to turn copper out of combination than hydrogen. So if copper were the real primary ion there is no call for hydrogen to appear. It looks, therefore, as if hydrogen were at least a primary ion, and possibly the only one. But, then, as pointed out by Smee, local exhaustion of the liquid near the cathode may cause such a deficiency of copper in the liquid touching the plate, that, if the current is too intense for diffusion to keep up the supply, hydrogen must perforce be liberated from the simple acid coating of the cathode. Hence in repeating any experiment of this kind it will be necessary to stir or scour the plate constantly and vigorously; and even then there would be some uncertainty about the matter, supposing hydrogen

* *Wied. Ann.*, XXIV., p. 52, 1885; *Ibid.*, XXV., p. 601, 1885.

† From the Report of the British Association.

‡ This fact, that no crossflow between "multiple arc" conductors must occur, if their combined conductivity is to be the sum of their separate conductivities, is sometimes overlooked. The covering on ordinary wires supplies the necessary condition; but if the wires touch the law breaks down. To the parts of one conductor the "divided circuit law" is by no means necessarily applicable.

§ Meaning always by "intensity" of current, *strength of current, per unit area*, or what is sometimes inconveniently styled "density" of current.

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persistently appeared. Is there any more direct and simple mode of answering the question as to whether the salt or the water, or both conduct the current? Yes, what seems to me a very simple and satisfactory one; by determining at which pole free acid appears, and, if it appears at both, by determining how much appears at either.

For the sake of clearness, it may be well to point this out in detail, though, indeed, it is so simple as hardly to be necessary. Consider a solution of copper sulphate in water, decompose it with platinum electrodes, and first make the assumption that the *salt* conducts the whole current, or that the real ions are Cu and SO_4. At the cathode Cu appears and is deposited—nothing else happens. At the anode SO_4 appears, decomposes water, forming sulphuric acid, and setting free oxygen. Thus, on this hypothesis, all the free acid appears at the *anode*. Next make the the assumption that *water* conducts the whole current, so that hydrogen and oxygen are the true ions. At the anode oxygen appears and is liberated—nothing else happens. At the cathode, hydrogen appears, decomposes $CuSO_4$, forming sulphuric acid, and setting free copper. So on this assumption, all free acid appears at the cathode. Finally, let the water conduct $\frac{1}{x}$th, and the salt $\frac{x-1}{x}$th of the current, then the ratio of the free acid formed at anode to that formed at cathode will be $x-1$.

Now, I have made many preliminary experiments, avoiding porous partitions of course, as introducing electric endosmose, capillary forces, and all kinds of unknown disturbances, using only two vessels connected with a syphon U tube, and other such arrangements. I find in all cases acid at *both* poles, though with *platinum electrodes* usually most at anodes. I do not press these preliminary results; a great deal of easy quantitative work suggests itself in this connection, and it is necessary to specify and to vary the concentration of solution and the strength of current used. The *method* is the important thing, and I should like to have it either approved or condemned. If one uses copper electrodes, the results are somewhat different. On the hypothesis that the salt alone conducts, no free acid should be formed anywhere; the solution should become impoverished at cathode and concentrated at anode—phenomena which are well known to occur to a greater or less extent. If, on the other hand, the water alone conduct, free acid should appear at cathode, but not at anode; the solution near cathode should again become impoverished of copper, though not of SO_4, while upon the anode is liable to form a coat of oxide which there is no sufficient supply of free acid near to dissolve off. And all these phenomena are also found to occur. The deposit of oxide on a copper anode is with intense currents most marked, so much so as almost to stop them. It is most instructive to put some dead-beat instrument like Ayrton and Perry's ammeter into circuit with a copper voltameter too small for the current, and watch the needle descend from the stops quickly almost to O*. Free acid *does* make its appearance at the cathode, and, with intense currents, plenty of it. Roughly one may judge perhaps that the salt conducts about three fourths of the current and the water one fourth, but I have no certain data yet for any such statement; and the proportion may well vary, for all I know, with the current intensity. One may, however, definitely accept hypothesis 3 or 4 as certainly truer than 1 or 2. The fact that acid is produced at anode, and alkali at cathode, in the decomposition of, say, sodic sulphate, proves that the salt conducts at least some of the current, and an estimation of the amount of acid and alkali respectively generated would decide what proportion was so conducted.

Again, experiments with electrolytes in series, as made by Hisinger, by Berzelius and by Davy, are interesting in their bearing on this point.† Thus, take three vessels containing say HCl, HNO_3, and AgNO, or Na_2SO_4, HCl, and $BaCl_2$, respectively; and the formation of a precipitate is a good identification of a true ion. The *locality* of such precipitate is still more instructive, since it conveys information as to the relative rates at at which the opposite ions travel, and so leads us on to the next question, concerning what is called the "migration of ions."

II. The Migration of Ions.

Do the Opposite Ions in Solutions Travel at Different Rates? And in any case, at what Rate do they Travel?—Here, as is well known, we must draw a distinction between fused and dissolved compounds. Fused or homogenous electrolysis, in which no solution occurs, must always remain of uniform composition. Consequently, considering any bounded region exactly equivalent quantities of either ion must pass out of it, on the whole. It is not evident that the two constituents must pass out in opposite directions, but in so far as they pass out in the same direction there is no true electrolytic decomposition. There is only a kind of electric endosmose, affecting the level of the fluid as a whole. Given that the level remains uniform, and that ions are only liberated at electrodes, then it is plain that the opposite corresponding ions must pass through any imaginary plane in the fluid at the same rate in opposite directions, for, if not, the constitution of the fluid would not remain uniform. This argument fails to apply to dissolved salts, and it breaks down before long, even with fused salts if they dissolve one of the liberated elements, or any other body, because in a solution no necessity for uniformity of composition exists. One portion may be concentrated while another is quite weak, and it is well known that such weakening and concentrating actions do occur in electrolysed solutions, *e.g.*, to specify a hackneyed but sufficiently instructive case, in the electrolysis of dilute sulphate of copper. With copper electrodes the solution near cathode becomes weaker, while that near anode becomes stronger than before. If the anode is arranged above the cathode visible blue streaks descend; if the arrangement is inverted the top liquor gets almost clear. If platinum electrodes be used both sides get weaker; but the cathode side weakens two or three times as fast as the anode side. It is customary to explain these well known and perfectly certain experimental facts by the obvious and plausible hypothesis that the two ions do not travel both at the same rate through the liquid, but that the SO_4 travels quicker than the Cu. Such an explanation accounts for the phenomenon, but it does not follow that it is certainly the true explanation; and for the sake of examining it more particularly I may be allowed to suggest doubts concerning it. If these doubts have no sound physical basis their statement will only result in their removal, and can do no harm.

First, let us quickly see how the hypothesis of unequal velocity accounts for the unequal concentration of solution which is called migration. Let SO_4 travel, say, three times as fast as Cu, and consider an imaginary partition about the middle of the cell. Three atoms of SO_4 travel unit distance through it towards the anode, for every atom of Cu travelling unit distance in the other direction; but the number of the atoms of Cu and of SO_4 liberated against the electrodes in the same time is four of each; hence the anode region of the cell loses only one SO_4, while the cathode region loses three Cu. The reasoning may be made to look more general. Consider a compound, AC, arranged in two vessels with a joining tube. Let A be anion and C be cation, and let A travel n times as fast as C, so that through the tube we have n equivalents of A passing for every equivalent of C. By the time one equivalent of each ion has been liberated against the electrode the ions transmitted by the tube will be x and nx equivalents respectively; hence the anode vessel will have lost altogether $1-x$ equivalents of each ion, and the cathode vessel will have lost $1-x$ equivalents. But x and nx together convey the whole current, so $x+nx=1$.

Thus, then, we have as the respective losses of the liberated elements by the two vessels—

$$\text{Loss in anode vessel} = 1-\frac{n}{1+n}=\frac{1}{1+n};$$

$$\text{Loss in cathode vessel} = 1-\frac{1}{1+n}=\frac{n}{1+n}.$$

Hittorf's well-known expressions.

Or consider it this way: By the time one equivalent of copper has been deposited, and one of SO_4 has attacked either, the anode itself, if of copper, or the water in its neighbourhood, if of platinum, forming $CuSO_4$ in the one case, H_2SO_4 in the other—no matter which. By the time all this has happened, $3x$ atoms of SO_4 have passed from neighbourhood of cathode towards anode, and x of copper have gone the other way. The cathode liquid has thus lost $1-x$ of copper, and so must have lost $1-x$ of SO_4 too, no more and no less, or else it would contain isolated radicles. The anode liquid has gained these $1-x$ atoms of SO_4, and they may be also reckoned as $3x$, as we just now saw, wherefore $x=\frac{1}{4}$. The cell happens not to lose any SO_4 by deposition, but, instead, it either loses an equivalent of O or gains an equivalent of Cu according to the nature of the anode. So the final result in any case is a transfer of $\frac{3}{4}$ equivalent of SO_4 from cathode vessel to anode vessel, combined with a transfer of $\frac{1}{4}$ equivalent of Cu in the opposite direction; a net loss of $\frac{2}{4}$ equivalent of copper sulphate by the cathode solution, and, in the anode liquid, either a net gain of $\frac{3}{4}$ equivalent of $CuSO_4$, if the anode be copper; or a gain of a whole equivalent of H_2SO_4 combined with a loss of $\frac{1}{4}$ equivalent of $CuSO_4$, and of a whole equivalent of oxygen, if the anode be platinum. All this is in fair agreement with experiment. The only obviously weak place is that relating to the production of free acid. According to the above it ought to appear, if at all, only at anode. Now, in practice, if the experiment be tried, it will be found to appear at cathode too. Still, the local concentration changes are satisfactorily and very simply explained by this customary migration hypothesis.

But before we decide that the sufficieney of this explanation proves its necessity or actual truth, let us try whether we cannot get the same results on another and not only plausible, but really quite necessary, hypothesis, viz., the hypothesis that the solvent conducts some of the current as well as the salt dissolved; and let us see whether this alone will not account for the whole "migration" phenomenon, even though opposite corresponding ions be supposed to travel at equal rates. By drawing a scheme, say, for the electrolysis of $CuSO_4$ solution with platinum electrodes, we can soon see that this hypothesis will do what is wanted; for we find that if $CuSO_4$ conducts the whole current, the decomposed equivalent comes half from each half of the cell—the anode half and the cathode half; whereas, by supposing H_2O to conduct the whole current $CuSO_4$ is decomposed by secondary action only in the neighbourhood of the cathode, and the amount of salt in the anode portion of the solution remains unchanged. The proper apportioning of conduction, therefore, explains migration just as well as the direct Hittorfian hypothesis. Moreover, we shall find that this mode of regarding the subject is capable of explaining the formation of free acid or other secondary products exactly where experiment shows them to be formed. If it be found to account for their appearance in precisely right amount, it may be held to to be proved; let us therefore examine more closely the full effect of supposing the current to be shared between the two ingredients of a doubly compound liquid in any assigned proportion.

Theory of Double Electrolysis, or the Decomposition of a Mixture of two Substances.—We must begin by excluding the possibility of double decomposition or interchange of radicles, because if such occur there are really not two substances mixed, but four. No stress is to be laid on the word "mixture," as distinct from combination; and I shall consider a solution of copper sulphate as a mixture of $CuSO_4$ and H_2O, dilute acid as a mixture of acid and water, without troubling about the perfectly certain fact that all these cases (and probably most other cases) of mixture are really cases

* Hence in arranging voltameters the anode should be larger than the cathode.

† An old experiment of Faraday's ("Exp. Res. 494) on "The formation of magnesic hydrate at a junction of Epsom salts and water, when a current passes, is now accepted even by Kohlrausch as proving that water may in some cases conduct."

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of—it may be very feeble—chemical combination. But commonly-called "mixed" solutions, such as the heading might at first sight suggest, like, say, KI+NaCl, or even KI+KCl—are excluded, not only by double decomposition, but by the presence by water, which is distinctly a *third* substance.

Limiting ourselves strictly, then, to two substances—*e.g.*, a salt and water, there are still several possible cases :—1. The liberated ions may belong wholly to one of the two compounds. 2. The liberated ions may belong one to each of the two compounds. 3. They may each belong to both.

At first sight the first case is a mere simple decomposition, like that of a fused salt, but not necessarily so. It all depends upon whether the substance is *primarily* decomposed or not—*i.e.*, or whether it conducts the whole current or not. If the other substance, whose ions are not liberated, either wholly or partially, conducts the current, it is a true case of double electrolysis.

To simplify the problem, we will use unalterable electrodes—*e.g.*, platinum, and we will suppose that the liberated ions do not dissolve, or at any rate *have not* dissolved, in the liquid, else the mixture will not remain merely dual, but will become more complex.

We have next to make some hypothesis concerning the relative speeds of opposite corresponding ions, *i.e.*, of the anion and cation of one and the same substance. For the sake of simplicity, I will first make the simplest assumption, in favour of which several considerations may be urged, though none of them are conclusive, viz., that opposite corresponding ions travel at equal opposite rates. We shall find this sufficient to explain every migration phenomenon, and we can see the effect of generalising it afterwards. Consider now the mixture, A C+A′C′, where A and A′ stand for anions, C and C′ for cations. Let the current be conducted by these two compounds in the ratio λ to λ, so that $\lambda+\lambda'=1$; and, in order to isolate the portion of the liquid near either electrode and study the changes therein occurring, we may picture the whole fluid as contained in two vessels united by a siphon tube, and we shall call the two vessels the anode vessel and the cathode vessel respectively. Further, we may, if we like, think of A C as sulphate of copper, and of A′ C′ as water. The product of deposition or liberated ions will then be C and A′ respectively, and the bye-product A C′ will be free sulphuric acid. This example, therefore, belongs to case (2) above, one ion belonging to each compound, and this will serve well enough as an example to work out.

Picturing the convection of electricity by the ions through the tube, we see that A carries a quantity of negative electricity $\frac{1}{2}\lambda$, A′ a quantity $\frac{1}{2}\lambda'$; C carries $\frac{1}{2}\lambda$ of positive electricity, and C′ a quantity of $\frac{1}{2}\lambda'$. So by the time a unit quantity of electricity has been conveyed, and an equivalent of anion and cation deposited on anode and cathode respectively, the following changes have occurred in the ingredients of the fluid in the two vessels. The cathode vessel has gained $\frac{1}{2}\lambda$ equivalent of C from the anode vessel, but it has lost a whole equivalent by deposition, so its net loss of C—which we may write dC—is $1-\frac{1}{2}\lambda$. Of the other cation it has lost none, and has gained $\frac{1}{2}\lambda'$ from the other vessel, so we may write $d\mathrm{C}'=-\frac{1}{2}\lambda'$. Of anodes it has lost some of both, but only by travelling to the other vessel, and accordingly $d\mathrm{A}=\frac{1}{2}\lambda$, and $d\mathrm{A}'=\frac{1}{2}\lambda'$. Similar reasoning easily applies to the anode vessel. Then passing from the elements only to consider the compounds, we recognise at once that a compound is lost by the loss of *either* of its elements, and that those elements may be either lost absolutely or may be found in new combinations. We thus soon perceive that the loss of the compound AC in the cathode vessel is equal to its loss of C, *i.e.*, to its major loss ; that is, $d(\mathrm{AC})=d\mathrm{C}=1-\frac{1}{2}\lambda$. The loss of A′C′ in this same vessel is equal to whichever is the bigger of the two losses dA′ or dC′ ; and as dC′ is, in the present instance, not a loss, but a gain, there is no doubt but that $d(\mathrm{A}'\mathrm{C}')=d\mathrm{A}'=\frac{1}{2}\lambda'$. Similarly with the other vessel.

But there remains to be considered what becomes of the unpartnered balance of all the various elements, for unless dC equals dA in both vessels, there will be in one or other an excess of either A or C—in the present case of A ; and, again, unless dC′ equals dA′ there will be an excess again in this case of the C′ ; hence we have the new compound a C′ formed: in amount, $d(\mathrm{AC}')=d\mathrm{A}-d\mathrm{C}=d\mathrm{C}'-d\mathrm{A}'$. The equality of dA−dC and dC′−dA′ is necessary, unless it is possible to obtain isolated ions ; and it will be found that they come out equal from the preceding values, and that $d(\mathrm{AC})=-\lambda'$ in the cathode vessel, while in the anode vessel $d(\mathrm{AC}')=-\lambda$.

Represent all this now in a table.

Result of Double Electrolysis on the liquid in anode and cathode vessels, by the time one equivalent of an ion belonging to each substance has been deposited :—

Substance.	Loss in cathode vessel.	Loss in anode vessel.	Total loss.
A	$\frac{1}{2}\lambda$	$-\frac{1}{2}\lambda$	0
A′	$\frac{1}{2}\lambda'$	$1-\frac{1}{2}\lambda'$	1
C	$1-\frac{1}{2}\lambda$	$\frac{1}{2}\lambda$	1
C′	$-\frac{1}{2}\lambda'$	$\frac{1}{2}\lambda'$	0
AC	$1-\frac{1}{2}\lambda$	$\frac{1}{2}\lambda$	1
A′C′	$\frac{1}{2}\lambda'$	$1-\frac{1}{2}\lambda'$	1
AC′	$-\lambda'$	$-\lambda$	−1

The facts of migration are thus perfectly accounted for, and a good deal beside. Thus free acid is shown to appear both at anode and cathode in the electrolysis of sulphate of copper with platinum electrodes: the amount at anode being $\frac{\lambda}{\lambda'}$ of that at cathode. Hence a determination of the relative amount of free acid in anode and cathode vessels at once gives a means of determining $\lambda:\lambda'$, the proportion in which the current is shared by the two substances, if the above hypothesis be true.

It is easy enough to put Hittorf's migration number n into the above table instead of λ : one has only to write $\frac{1}{2}\lambda=\frac{1}{n+1}$; but only three lines of the table have any meaning on the Hittorfian hypothesis—viz., the first, third, and fifth lines—relating to the loss of the compound AC in the respective vessels ; the solvent, or other compound, A′C′, is ignored, and the production of free acid near cathode is not supposed to occur. But it *does* occur, as some preliminary experiments I have made prove. Our hypothesis makes the formation of acid and everything else independent of intensity of current. Experiment may not confirm this ; but then we must remember that we have assumed no *mixture of ions* to be liberated, and it is known that with intense currents some hydrogen is given off at cathode as well as copper deposited. If this be taken into account the reasoning must, of course, be generalised.

A more formidable objection, however, may be made to the theory, viz., that it virtually assumes the conduction by the two sets of atoms to be independent ; for instance, the λ portion of current starting fairly away from the neighbourhood of electrodes *via* $CuSO_4$ is supposed to go through $CuSO_4$ all the way, and not to come across patches of water or to take either ingredient of the liquid at random. Consider for a moment what would happen if this did occur. Take a chain, $CuSO_4$, $CuSO_4$, H_2O, H_2O, H_2O, H_2O, $CuSO_4$, $CuSO_4$, H_2O. Imagine the usual Grotthus action to go on through the chain : the result is $2H_2SO_4$ and 1CuO. This is an unstable condition, or condition of non-minimum energy ; so one H_2SO_4 will combine with the CuO ; but it need not combine at once, because there is no need for the two compounds to be formed close together. Hence we must expect free acid sometimes to make its appearance *in the middle of the liquid away from either electrode*, and also for CuO to appear (in the form of some basic salt I suppose) too. Choosing proper materials, an action of this kind might be readily looked for, but I have never heard of its being detected, and it is so unlike what we know the behaviour of electrolytes in general that until proof to the contrary is forthcoming I feel compelled to believe that a current fairly starting in AC continues in it all the way, that a current starting in A′C′ likewise continues in that, and that secondary actions, or passage of current from AC to A′C′, only occur in the immediate neighbourhood of the electrodes.* It is easy to illustrate the preceding table of the changes in the solutions by a diagram of a special case :—

Scheme of Decomposition of Sulphate of Copper solution with platinum electrodes on the gratuitous assumption that water conducts $\frac{1}{4}$ the whole current :—

Cathode			Anode
←$CuSO_4$	$CuSO_4$	..... $CuSO_4$	$CuSO_4$
H_2O	H_2O	H_2O	H_2O ↑
←$CuSO_4$	$CuSO_4$	$CuSO_4$	$CuSO_4$
H_2O	H_2O	..... H_2O	H_2O ↑
←$CuSO_4$	$CuSO_4$	..... $CuSO_4$	$CuSO_4$
H_2O	H_2O	H_2O	H_2O ↑
←$CuSO_4$	$CuSO_4$	..... $CuSO_4$	$CuSO_4$
H_2O	H_2O	H_2O	H_2O ↑

The arrangement of the symbols indicates the constitution before passing the current ; the dotted lines and arrows indicate the state of affairs after four units of electricity have passed, on the arbitrary assumption (only made for the sake of illustration) that the $CuSO_4$ conducts three times as much current as the water does, *i.e.*, that $\lambda=\frac{3}{4}$ and $\lambda'=\frac{1}{4}$. Inserting these values in the previous table, and multiplying by four, to represent that four units of electricity have passed, it becomes :—

Substance.	Loss in cathode vessel.	Loss in anode vessel.	Total loss.
SO_4	$1\frac{1}{2}$	$-1\frac{1}{2}$	0
O	$\frac{1}{2}$	$3\frac{1}{2}$	4
Cu	$2\frac{1}{2}$	$1\frac{1}{2}$	4
H_2	$-\frac{1}{2}$	$\frac{1}{2}$	0
$CuSO_4$	$2\frac{1}{2}$	$1\frac{1}{2}$	4
H_2O	$\frac{1}{2}$	$3\frac{1}{2}$	4
H_2SO_4	−1	−3	−4

And all this is exactly borne out by the above scheme ; for one notes that 3 atoms of acid make their appearance in the anode vessel and 1 atom in

* It is assumed, in the text, that the ingredients of the liquid are thoroughly mixed. If they are purposely arranged in layers, free acid or free base may certainly make its appearance at the bounding surfaces. In fact, Faraday has observed the phenomenon, Exp. R. § 494 ; for he passed a current from strong $MgSO_4$ solution into "water" (*i.e.*, really weak $MgSO_4$ sol.), and found a deposit of magnesic hydrate at the layer of demarcation. It is interesting to note that in January, 1886, Kohlrausch accepts this experiment as proving that water does in some cases share in the conduction, though he still considers its share as negligible in all but exceedingly weak solutions.

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the cathode vessel; that ½ an atom of O is transferred one way, an ½ an atom of H_2 the other way; that ¾ atoms of Cu travel from anode vessel to cathode vessel, but that 4 are deposited, making the net loss in this vessel $4 - 1\frac{1}{2} = 2\frac{1}{2}$; and so on.

(To be continued.)

ON THE NUMERICAL VALUES OF CERTAIN COEFFICIENTS OF SELF-INDUCTION.*

BY MM. VASCHY AND DE LA TOUANNE.

The theory of electrical apparatus is generally established under the hypothesis that the current has already arrived at the permanent state. Although this method gives only a first approximation at the best, it was yet practically admissible during the earlier period of telegraphy when the currents transmittted had always a relatively prolonged duration, but it is very doubtful whether we ought to rest satisfied with this treatment under modern conditions where very rapid reversals or makes and breaks are quite usually employed. In these cases the receiving instrument is, or may be, always at work during the "variable period." This weak point in the usually accepted theory has often been indicated, and in a note published in the *Annals Télégraphiques* (p. 585; 1877) upon the winding of electro-magnets, M. Raynaud appended the remark that the formulæ which had been given required to be followed with circumspection in certain cases, inasmuch as no account had been taken of the duration of the extra current. Since this date several special cases have been studied, in particular by Mr. Oliver Heaviside,† but always from a purely theoretical point of view.

Amongst the phenomena which more directly intervene in the case of rapid transmission are those which relate to the self-induction. We can easily take account of this function in examining a simple case such as that of an electro-magnetic recorder acting in a local circuit under the influence of currents of very brief duration.

Let R be the resistance of the external circuit,
R′ ,, ,, battery,
E ,, E.M.F. ,, ,,
L ,, coefficient of self-induction for the whole circuit.

If we take for the commencement of the time t, the moment when the circuit is closed, the value i_1 of the current must satisfy the relation

$$(R+R')\,i_1 + L\frac{d\,i_1}{d\,t} = E;$$

from which on integrating

$$i' = \frac{E}{R+R'}\left(1 - e^{-\frac{R+R'}{L}t}\right) \quad . \quad . \quad . \quad . \quad (1)$$

For a time t, sufficiently prolonged to correspond with the permanent state, this reduces to the ordinary equation

$$i = \frac{E}{R+R'}$$

But this is not at all the case if we consider only the first instant of closure. Suppose that t is very small, so that in the development of $e^{-\frac{R+R'}{L}t}$ in a series we may neglect the terms of a higher order than the first, we have sensibly,

$$e^{-\frac{R+R'}{L}t} = 1 - \frac{R+R'}{L}t$$

Equation (1) then becomes

$$i_1 = \frac{E}{L}t \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1')$$

At the moment, then, of contact the self-induction acquires a preponderating importance, and the actual resistance of the circuit is negligible; the current has a value such as would be given (in the permanent state) if we had subsituted a resistance equal to $\frac{L}{t}$.

Now, if we take t equal to a very short period θ, and suppose that at the end of this period the current suddenly ceases, we may take the mean intensity of the current during the interval θ as

$$i'_1 = \frac{E}{L}\frac{\theta}{2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

So far we have made no hypothesis as to the grouping of the elements of the battery.

Suppose that $m\,n = K$ be the number of these cells, each having an E.M.F. equal to ε, and a resistance ρ; m and n representing respectively the number of cells in series and in parallel.

Equation (2) shows that the most advantageous arrangement when working with currents of brief duration corresponds to the case in which all the cells are connected in series. The current at the end of time t is then expressed by

$$i_1 = \frac{k\varepsilon}{R+k\rho}\left(1 - e^{-\frac{R+k\rho}{L}t}\right)$$
$$= \frac{m\,n\,E}{R+m\,n\rho}\left(1 - e^{-\frac{R+m\,n\rho}{L}t}\right) \quad . \quad . \quad . \quad . \quad (3)$$

Upon the other hand, we know that under the hypothesis of the permanent condition we should obtain the maximum effect when the resistance of the battery is equal to that of the external circuit. The current in this case is given by the formula

$$i_2 = \frac{m\,e}{R+\frac{m\rho}{n}}\left(1 - e^{-\frac{R+\frac{m\rho}{n}}{L}t}\right) \quad . \quad . \quad . \quad . \quad (4)$$

where $$\frac{m\rho}{n} = R$$

The curves I. and II. (Fig. A) are drawn from the formulæ (3) and (4) respectively, the time t being taken as abscissæ, and value of

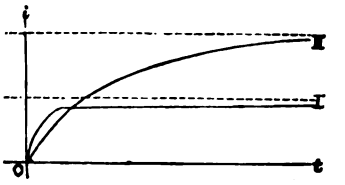

FIG. A.

current as ordinates. During the first moments of contact curve I. rises above curve II., but if the contact be prolonged the latter gives the greater current. The grouping of battery cells, which is habitually given as the most favourable, is therefore not advantageous for circuits upon which very brief contacts are employed. Practical experience has already confirmed these theoretical deductions. For instance, the coils of the relays employed with the Wheatstone apparatus are found to give better results when joined in parallel, and Mr. Preece recently mentioned the case of two relays, one of which permitted the transmission of 400 to 450 words per minute, while the other could not be worked beyond 50 or 60, the only difference between the two being in the value of their coefficients of self-induction. It has again been found necessary in the systems of harmonic telegraphy to increase the number of cells in the battery considerably beyond the number which would be required upon the same line by the ordinary methods of working. The same observation applies to all other systems in which very brief contracts are made, and it is certain that in these cases the currents actually transmitted have much smaller values than would be given by the simple application of the law of Ohm.

Self-induction has again much to answer for in the cases of damage resulting to telegraphic apparatus from lightning. The discharge is of such brief duration that the self-induction actually determines a virtual resistance in the coil superior to that of the insulation between the wire and the magnet cores. The insulator is consequently perforated. In the case of lightning conductors, self-induction is therefore by no means a negligible term. M. von Helmholtz and Sir William Thomson called attention to this fact in the discussion upon lightning conductors at the International Congress held at Paris in 1881, without, however, attributing to this function the predominating importance which it probably has.

From what has hitherto been said one might be led to suppose that the influence of self-induction was always of an injurious character. This is not, however, invariably the case. Take, for example, the multiple synchronous telegraph of M. Delany.* In this apparatus the current passes at the receiving station through the coils of an ordinary Morse instrument, but instead of being continuous from the sending station during the time in which each signal, whether long or short, is being made, the current transmitted is really a succession of very short impulses, and the interval between each said impulse is five times as long as the actual contact. Nevertheless, thanks to the influence of the self-induction in the coils, and by the aid of a condenser, the tongue of the relay is continuously attracted during each such signal, so that the instrument works in the same manner as if the currents were actually continuous.

Lastly, we know that self-induction plays an important part in dynamo machines, and that it is impossible to make an adequate study of the condition of telephonic transmission without taking this factor into account. One of us has already written upon this subject,† but the corresponding measurements are very difficult to carry out.

* Memoir presented to the Société Internationale des Electriciens.
† *Journal* of the Society of Telegraph-Engineers, 1878.

* See *The Electrician*, May 7, 1886.
† *Annals Télégraphiques*, pp. 185 and 463; 1884.

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Although it is not our intention at present to deal at length with the various problems indicated below, and we intend to make a separate study of many of them, yet we believe that it will be useful to make known at once the numerical results obtained in a first series of experiments, and the principle of the method that we have employed. And as the subject is one that has been very rarely dealt with, we think that these figures will be found to possess some interest.

In the following table, R is the resistance, L the coefficient of self-induction, and M the coefficient of mutual induction for each apparatus. We postpone the description of the methods employed until these results have been stated.

	R (in ohms).	L.
Morse receiver, in working order, armature raised.	500 ...	6·37
Ditto ditto armature resting on core	500 ...	10·68
Ditto coil, 1 without core	242 ...	0·233
Ditto 2 ,, ,,	242 ...	0·265
Ditto 1 with core	242 ...	1·66
Ditto 2 ,, ,,	242 ...	1·71
Telephone Annunciator, "Law" system	179 ...	0·915
Bobbin, with three similar coils wound side by side; each coil	200 ...	—
Coil No. 1	— ...	0·465
Coils 1 and 2 in series	— ...	1·76
Coils 1, 2, and 3 in series	— ...	3·94

(N.B.—It will be observed here that L increases very nearly as the square of the number of turns.)

TELEPHONE RECEIVERS.

Type.		
D'Arsonval	219 ...	0·15
Boisselot	87 ...	0·026
Siemens	227 ...	0·17
Teillouse	197 ...	0·101
Ader	50 ...	0·021
Telephonic induction coil—		
Primary	— ...	Inappreciable.
Secondary	200 ...	1·105

M=0·14.

Induction coil with two independent secondaries, and two separate cores consisting of split iron tubes—			
Secondary, No. 1		305 ...	0·75
,, No. 2		311 ...	0·81
Primary		163 ...	0·74
	M		
Secondary No. 1, with primary	0·58	—	—
,, No. 2 ,,	0·64	—	—
Secondaries 1 and 2	1·27	—	—

We have employed two distinct methods in making the measurements of self-induction, one being a bridge method, and in the other making use of a differential galvanometer. For the measurement of mutual induction we have employed a special zero method.

Differential Galvanometer Method.—Fig. 1 shows the connections employed. L is the coil or apparatus to be measured; C a condenser connected to the terminals; A and B, of a rheostat r without self-induction; S a shunt in the battery; f f' a stretched wire, having a sliding contact piece K'.

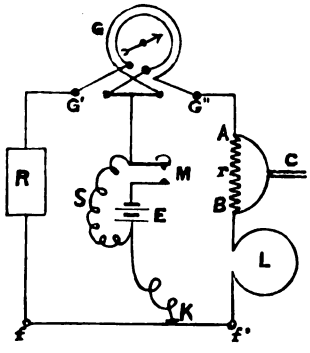

FIG. 1.

We first depress the battery key M, then by means of the variable resistance R (which is also without self-induction) we establish approximate equilibrium of the current in the two branches of the galvanometer. We then remove the shunt on the battery, and make a final adjustment by means of the slider K. Equilibrium being thus obtained, we open the key M, and observe the throw (a) of the needle. We now remove the condenser of capacity C, replace it by another whose capacity is C', and take a second reading (a'). It can then be shown that we shall have

$$\frac{L-Cr^2}{a}=\frac{L-C'r^2}{a'}$$

whence

$$L=\frac{C'a-Ca'r_2}{a-a'}.$$

As a verification we can take a fluid reading (a'') with another condenser, and on combining this with both a and a' separately we should have three equal results.

For high values of L it is advantageous to proceed in the following way:—Take C=0, this makes a very large; then find by trial such a value for C' as will make a' as small as possible. We have then

$$L=C'r^2\left(1+\frac{a'}{a-a'}\right)$$

This is practically a zero method, with the addition of a correction term $\frac{a'}{a-a'}$ when the value a' cannot be made to disappear altogether with the values of capacity at our disposal. (In our experiments we made use of a condenser of five microfarads graduated in hundredths of microfarad.) This zero method avoids errors due to any variation in the battery between the two readings, or to an incorrect graduation of the galvanometer scale, &c.

We have taken for granted that the self-induction of the other parts of the circuit is negligible. If this is not the case, and especially when L is of small value, we must deduct from both a and a' the value a_0 which is obtained when L is replaced by a coil of the same resistance, for which the self-induction is negligible, at the same time making C=0. We have then

$$\frac{L-Cr^2}{a-a_0}=\frac{L-C'r^2}{a'-a_0}$$

In the case where L is a straight wire this correction is not sufficient, and the method is not applicable.

Wheatstone Bridge Method.—Fig 2 shows the corrections for the bridge test. The coil L, the resistance r, and the condenser C, are placed in one branch of the bridge. The keys are manipulated in the same way as before, the variable resistance c serving to make the preliminary adjustments. We obtain the same formula,

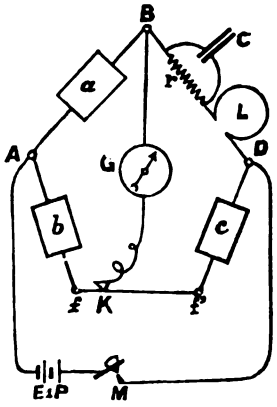

FIG. 2.

$$L=\frac{C'a-Ca'r^2}{a-a'}$$

By this method we were able to take a measurement for values of L as low as 0·006 with an accuracy of 10 per cent. with a current of 0·005 amp. For larger values of L the precision of the method is much greater, and might easily be increased, if necessary.

Measurement of the Coefficient of Mutual Induction.—In Fig. 3 M represents the two coils whose mutual induction is to be measured.

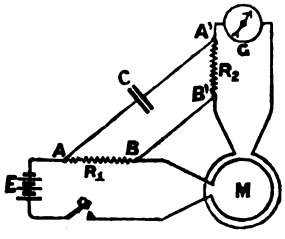

FIG. 3.

The primary is placed in circuit with the battery E, a rheostat R_1, and a key. The secondary circuit contains a galvanometer, G, and rheostat, R_2. The terminals A and B of the first rheostat are joined

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respectively to A′ and B′ of the second, the wire AA′ being interrupted by the condenser C. When the primary circuit is closed the galvanometer needle makes a throw (α) which is due to the combined effects of the condenser and the induced current in M. On opening the primary circuit we should get an equal throw in the contrary direction. If we repeat this operation with a condenser of capacity C′, we get a second reading (α'). We have then the equation

$$\frac{M - C R_1 R_2}{\alpha} = \frac{M - C' R_1 R_2}{\alpha'}$$

where M is the coefficient of mutual induction ; whence

$$M = \frac{C'\alpha - C\alpha'}{\alpha - \alpha'} R_1 R_2$$

If M is very large, we may first make C = 0 ; next we find by trial a value for C′ which will make (α') zero, or as small as possible. We have then

$$M = C' R_1 R_2 \left(1 + \frac{\alpha'}{\alpha - \alpha'}\right)$$

This is a zero method, with the correction term $\frac{\alpha'}{\alpha - \alpha'}$.

We have found one cause of trouble and error in these measurements arising from the bad insulation between the two coils.

In all measurements of induction in or to avoid the use of general formulæ of a very complicated character it is necessary, (1) to place the coils whose induction is to be measured at a distance from the rest of the circuit ; (2) to make sure that the self- and mutual induction in all other parts of the circuit is negligible.

INCANDESCENT LAMP PATENTS.

Yesterday a meeting of "engineers, incandescent lamp makers, and important shareholders in the leading Electric Light Companies" was held at the Cannon-street Hotel, having been convened by Messrs. Shippey Brothers.

Mr. ARTHUR SHIPPEY said that it had been intended to ask Dr. Woodward, one of the earliest inventors of incandescent lamps, to take the chair, but that gentleman was in Liverpool. He therefore proposed that General Alexander should take the chair.

The CHAIRMAN then stated that he was not an electrician, but he took a great interest in electricity ; and he was very proud at having been invited to preside over such a meeting.

Mr. ARTHUR SHIPPEY addressed the meeting at some length, and after entertaining the company with his views on the present position of the electric lighting industry, he proceeded to observe that the Edison and Swan Company were elated at their success in the action with Messrs. Woodhouse and Rawson, but in that case there was going to be an appeal. The Edison Company, after their success, issued a notice to users of the lamps made by his firm, who had not had any notice from the Company, that they were infringers, and he was happy to say that at the trial they would be able to prove that they were not. He thought it would be best to call that meeting in order, if possible, to frustrate the attempt of the Edison and Swan Company to obtain a monopoly. He then gave a history of the principal incandescent lamp patents since the year 1838. The incandescent lamp was not, he said, due to the inventive genius of either an Englishman or an American, but to a Belgian, M. Jobard, of Brussels, who, however, did not actually make a lamp. The first idea, however, emanated from that gentleman, whose pupil, M. de Chanay, took up the question with earnestness. For many reasons he (Mr. Shippey) maintained that the Edison and Swan Company were not entitled to a monopoly. He thought that electric lamps might be divided into four classes — arc lamps, semi-incandescent lamps, incandescent lamps of high resistance, and glow lamps of low resistance. The incandescent and glow lamps should be defined in order to prevent complications for the future. He had seen about 140 patents in connection with incandescent lamps ; but to his mind there were only four lamps in existence worthy of the name of patents connected with the branch of incandescent lighting. The four which would stand on their merits were the Lane-Fox and the Edison lamps for high resistance, which he considered were the best lamps for running in parallel, and for central station lighting. Mr. Edison was entitled to the sole right to manufacture lamps of 100 to 500 ohms resistance, as shown by his specification. The other two lamps he referred to were those in connection with the Zanni-Shippey inventions (under which he claimed the manufacture of lamps up to 50 ohms registered), and the Bernstein lamp, which was also a lamp of low resistance. With the amalgamation of these four he considered that they had all they required—lamps for parallel lighting, lamps for series lighting, lamps for single domestic installations. There was an action pending against the Anglo-American Brush Corporation, and his firm had an action against the Edison and Swan Company for interfering with their customers. They were quite prepared to fight that action, but it would cost a good deal of money ; and he appealed to the meeting to express their opinion as to the best course to be adopted with the view to frustrate a monopoly. They would be saved some £3,000 by the action in which Messrs. Woodhouse and Rawson had been engaged, as they would simply bring forward in their action new features, which, he said, would have the effect of causing judges to hold a different opinion from that which they expressed in the late action.

Mr. LOVERING then proposed the following resolutions :—

1. That this meeting hereby expresses its opinion that the course of action adopted by the Edison and Swan Electric Light Company towards customers using incandescent lamps and against the makers and vendors thereof is highly detrimental to the development of electric lighting.

2. That Mr. Shippey's firm be requested to actively defend the said action, and avail themselves of every possible opportunity of frustrating the threatened monopoly of the incandescent lamp trade by the said Edison and Swan Company.

3. That a committee be formed for the purpose of watching and protecting the interests of the trade, and assisting makers, vendors, and customers of lamps in resisting the action taken by the said company, and that the following gentlemen be appointed to act upon such committee (the names were filled in afterwards) and report to a subsequent meeting of the trade to be convened by them ; power being reserved to add to the committee.

4. That a fund be subscribed for the purpose of enabling the committee to resist the action taken by the said company.

Mr. LE FEVRE seconded the motion, observing that he had no interest in the matter except that he desired to see fair play done.

Mr. JOEL took exception to the contention of Mr. Shippey as to the four patents enumerated by that gentleman. There were other patents undoubtedly. For a committee to do any good it ought to be as influential and general as possible.

Mr. FYFE also spoke, moving that the committee be appointed for the purpose of investigating the information supplied by Mr. Shippey. This amendment was, however, lost sight of by the meeting.

Mr. SHIPPEY stated that the committee to be formed that day would be only provisional.

The following gentlemen were then appointed members of the committee :—Mr. Fyfe, Mr. Joel, Mr. Tongue, Mr. Shippey, Mr. Lovering, General Alexander, and Mr. Le Fevre.

These names were included in the third resolution, as above.

The CHAIRMAN put the resolutions, which were agreed to ; and they were afterwards signed by the Chairman on behalf of the meeting.

The usual complimentary vote brought the proceedings to a close.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. AUG. 25.		BUSINESS DONE WEEK ENDING AUG. 25. Highest.		Lowest.	
Anglo-American	33,	34	.....	—	.....	—
Do. Preferred	54½,	55½	.....	55⅝	.....	54¾
Do. Deferred	11,	11½	.....	—	.....	—
Brazilian Submarine	10½,	10¾	.....	10⅝	.....	10½
Cuba	11,	11½	.....	11½	.....	11½ xd.
Do. Preference	18,	19	.....	—	.....	— xd.
Direct Spanish	1½,	2	.....	—	.....	—
Do. Preference	9,	10	.....	9⅝	.....	9½
Direct United States Cable	9,	9½	.....	9 1-16	.....	9
Eastern Telegraph	11½,	11½	.....	11 7-16	.....	11⅝
Do. 6 per Cent. Preference	14½,	14¾	.....	14⅝	.....	14½
Do. 5 per Cent. Debentures, 1899	105,	108	.....	—	.....	—
Eastern Extension	12⅜,	12⅝	.....	12½	.....	12 5-16
German Union	9½,	9¾	.....	—	.....	—
Globe Telegraph and Trust	6½,	6¾	.....	6 7-16	.....	6½ xd.
Do. Preference	13½,	13⅝	.....	13 5-16	.....	13½ xd.
Great Northern	12½,	13	.....	12¾	.....	12 11-16
Indo-European	36,	37	.....	—	.....	—
Reuter's	6,	6½	.....	—	.....	—
Submarine	190,	200 xd.	.....	—	.....	—
West India and Panama	⅝,	⅞	.....	—	.....	—
Do. 1st Preference	8¾,	9½	.....	9½	.....	8¾
Western Brazilian	6¾,	7	.....	—	.....	—
Western Union 7 per Cent. 1st Mortgage	118,	122	.....	—	.....	—
Do. 6 per Cent. Sterling Bonds	103,	107	.....	—	.....	—

TELEPHONES.

Consolid. Telephone and Maintenance	13-16	15-16	.....	—	.....	—
Oriental	3-16	5-16	.....	—	.....	—
United Telephone	13⅜,	13⅝	.....	13⅝	.....	13⅜

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	2,	2½	.....	—	.....	—
Do. (fully paid)	3¾,	4¼	.....	—	.....	—
Swan	¾,	1⅛	.....	—	.....	—
Maxim Weston	3-16	5-16	.....	—	.....	—

MISCELLANEOUS.

Telegraph Construction	37½	38½	.....	38¼	.....	38⅜
India Rubber, Gutta Percha, and Telegraph Works	23	24	.....	24	.....	—

TRAFFIC RECEIPTS FOR JULY, 1886.

COMPANIES.	July, 1886.	July, 1885.	Increase.	Decrease.
Cuba Submarine	2,800	2,517	283	—
Direct Spanish Telegraph	1,270	1,284	—	14
Eastern Extension	34,931	46,099	—	11,168
Eastern Telegraph	43,708	48,081	—	4,373
Great Northern	23,000	—	—	—
West Coast of America	8,050	—	—	—

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NOTES.

THE SCILLY ISLANDS.—Telegraphic communication with the Scilly Islands is interrupted.

MEXICO.—The Mexican journals are agitating for the removal of overhead wires from the streets of the capital.

LUCERNE.—The electric light installation at Lucerne, of which we have already given a description, has now commenced active operations.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 27th ult. amounted to £3,368.

CABLE DIVIDEND.—The Directors of the West Coast of America Telegraph Company have declared an interim dividend of 2s. per share.

POST OFFICE TELEGRAPHS.—Mr. G. O. Davies, sorting clerk and telegraphist at Birmingham, has been appointed postmaster of Ruabon.

THE NEW EDISON FACTORY.—The new factory which is being built for the Edison Company of New York will, when complete, afford accommodation for 1,200 mechanics.

EASTERN TELEGRAPH COMPANY.—The traffic receipts of this company for the month of August amounted to £44,091, against £47,968 in the corresponding period of last year.

THE ELECTRIC LIGHT IN BOURNEMOUTH.—Messrs. Mortimer, Shepherd, and Co. announce an exhibition of the electric light (arc and incandescent lamps) in the Arcade, Bournemouth.

LIGHTING FERRY BOATS BY ELECTRICITY.—The *Dundee Advertiser* says :—"The Tay Ferries Committee have under consideration the matter of fitting up the two ferry steamers with the electric light."

RHEIMS.—During a severe thunderstorm the great rose-window at the cathedral of Rheims, one of the most magnificent specimens of the art of the mediæval glass worker, was last week entirely destroyed.

SPANISH TENDERS.—Tenders for the supply of 20,000 bottles of blue ink for the Spanish Telegraph Service will be allotted on the 24th inst. Specifications and conditions are on view at the Madrid office.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY.—The traffic receipts of this company for the month of August amounted to £34,687, and to £41,987 in the corresponding period of 1885.

BRUSSELS.—The General Post Office at Brussels is now lit by electric light. Four arc lamps, two *lampes soleil*, and a large number of incandescent lamps are hung. The dynamo is driven by an engine of 46 horse-power.

THE TELEPHONE IN AFRICA.—The Portuguese settlement at St. Paul, Loanda, possesses a telephone exchange. The number of subscribers is at present sixty-one, and the annual rate is extremely low, being only £6 per annum.

PATENT LAW IN THE UNITED STATES.—The Congress of the United States has under consideration a proposal for extending patent rights in certain cases, at the discretion of the Commissioners, for an additional period of eight years.

ELECTRIC LIGHT AT CHERBOURG.—It is proposed to strengthen the defences of Cherbourg by providing two fixed electric lights which shall illuminate the channels upon either side of the breakwater within which the arsenal is situated.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending 21st ult. were £2,479, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

EXHIBITION AT THE PALAIS DE L'INDUSTRIE.—Although Paris is reserving its energy for the great Exhibition of 1889, yet a very interesting "Exhibition of Arts and Sciences" is now being held at the Palais de l'Industrie. Electricity, of course, plays a very prominent part.

TELEGRAPHIC MONEY ORDERS.—In the House of Commons on Tuesday, the Postmaster-General, replying to Mr. Shirley, stated that he had not yet had time to consider the suggestion for establishing a telegraphic money order system, but that it should receive his attention during the recess.

ELECTRIC TRICYCLE.—We hear of another tricycle to be driven by accumulators. This machine has been brought out in the States. We fear, however, that it is scarcely possible to achieve any real success in this direction until the storage capacity of accumulators has been greatly increased.

THE INDIAN TELEGRAPHS.—It is feared that the concessions reported by telegraph to have been made by the Secretary of State as to reorganising the telegraph department will not satisfy the desires of the Indian Government servants. The subject, it is anticipated, will have to be again considered at the India Office.

REDUCTION OF TELEPHONE TARIFFS. — The Western Counties and South Wales Telephone Company have reduced the tariffs for connections with the private residences of the subscribers to their exchange to the following rates :—Under quarter of a mile, £5 ; under half a mile, £6. 5s. ; under one mile, £8. 15s.

SIGNALLING BY INCANDESCENT LAMPS.—M. O. Kalezowski, of Berlin, has suggested that when incandescent lamps are used for signalling at night for military or naval purposes the switches should be actuated by means of a modified Wheatstone transmitter, so that the punched tape may be retained as a record of the message.

"L'INGENIEUR ELECTRICIEN."—We have received a copy of a new weekly electrical journal published at Paris under the above title. The contents of the first two numbers are varied and interesting. We note that in the next issue it is proposed to give a *resumé* of all the criticisms upon the recent experiments of M. Deprez which have hitherto appeared.

NEW TELEGRAPHIC CABLE.—A new telegraphic cable is now being laid between Ireland and England to connect Dublin and London by a fresh route. The ss. "Monarch" has already laid the Welsh shore end, which starts from Nevin in Pembrokeshire. In connection with this line a special copper wire is being run between Nevin and London.

THE LISBON TELEPHONE SERVICE.—Strong complaints are made in one of the Portuguese papers as to the extremely unsatisfactory nature of the telephone service in Lisbon. It is alleged that the utmost difficulty is experienced in obtaining communication through the central office; and that many subscribers have decided not to renew their subscriptions.

THE BOSTON STREET RAILWAY.—The directors of the Boston Street Railways have determined to adopt either electric or cable traction for the whole of their extensive lines, and have appointed a committee to visit various towns in the States to investigate the practical working of each system. It is probably a foregone conclusion in favour of electricity.

NEWCASTLE-ON-TYNE INTERNATIONAL EXHIBITION, 1887.—We have received a copy of the prospectus of the Newcastle-on-Tyne Mining Engineering and Industrial Exhibition,

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which is to be held next year. Electric lighting is entered in Division 10, under the head of Hygiene, and electric appliances in Division 14, under the head of Science and Education.

PRESS TELEGRAMS IN GERMANY.—There has recently been a good deal of grumbling in Germany over the revised press tariffs. Nevertheless, the use of the telegraph by the more important journals continues to increase. A recent number of the *Frankfurter Zeitung* contained no less than 23,900 words of telegraphic intelligence. Of this, 13,700 words were parliamentary, and the remainder general news.

THE INSTITUTE OF MECHANICAL ENGINEERS.—During the recent summer meeting of this body, at which a large number of Belgian engineers were present, among the places of interest which were visited were the works of Messrs. Crompton and Co. at Chelmsford, the works of the Anglo-American Brush Corporation at Lambeth, and the electric light installations at the Holborn and the Criterion Restaurants and at the Princes Theatre.

A TELEPHONE RAID.—The whole of the departmental offices of the United States Government were recently required to make a return of the number of telephone instruments in their possession. A committee is investigating the matter, and has already ordered the number of telephones in the offices of the executive at Washington to be reduced by 50 per cent., and it is expected that a similar reduction will take place throughout the service.

ELECTRICITY ON THE FRENCH RAILWAYS.—The French Minister of Public Works has appointed a technical commission, consisting of State engineers, and presided over by M. Lucas, engineer of highways and bridges, to inquire into the practicability of applying electricity to the working of railways in the matter of signalling, announcing the arrival of trains by electric bells, intercommunication between trains in motion, and the working of continuous brakes.

THE REGENT PRIMARY BATTERY.—The prospectus is issued of the Regent Portable Electric Lamp and Lighting Company (Limited), with a capital of £85,000 in 17,000 shares of £5 each. The company is formed, among other things, to acquire the "exclusive licence to manufacture and sell in the United Kingdom and the Isle of Man" the Regent Primary Battery, particulars of which have from time to time appeared in our columns. The list of application for shares closes to-morrow (Saturday).

EDISON-SWAN COMPANY *v.* WOODHOUSE AND RAWSON.—We understand that pending the hearing of the appeal in this case, a mutual arrangement has been made by which Messrs. Woodhouse and Rawson have agreed to pay a royalty upon all lamps sold by them, the royalty to be returned in case the appeal is successful. The effect of this arrangement will be that if the appeal should be unsuccessful, the purchasers of Woodhouse and Rawson lamps will still be free from any claim on the part of the Edison-Swan Company.

TELEGRAPHS ON THE WEST AFRICAN COAST.—The West African Telegraph Company has received telegraphic information from the Gold Coast and West Africa, announcing the opening to the public service on the 28th ult. of this Company's stations at Accra, Grand Bassam, Porto Novo or Kotoonon, and on the island of St. Thomé. It is expected that the station of Principé will be opened on the 31st ult., and that shortly after that date Gaboon and St. Paul de Loando will be in telegraphic communication with Europe.

GUATEMALA.—The city of Guatemala is lit by 250 arc lights supplied by six Thomson-Houston dynamos, which are driven by water power. The total length of the five circuits (one machine being spare) is over sixty miles. The wires are carried along the fronts of the houses, under the eaves. Good insulation is thus secured. The city also possesses a telephone exchange, with over 200 subscribers. The charge for the exchange service is $5 per month. The country is well supplied with telegraph lines, which are effectively administered by the Government Department of Posts and Telegraphs.

ELECTRIC LIGHT AT THE BIRMINGHAM ART GALLERY.—The arrangements for illuminating the rotunda at the Art Gallery with the electric light are now complete. The illumination is accomplished by a large ring of Swan incandescent lights, backed by carved reflectors of silvered glass, so arranged as to direct the light towards the walls. The light is very brilliant, and the colours of the various paintings are seen even better than by daylight. The critics say the only disadvantage is that the brilliancy of the rotunda makes the other rooms dull by comparison. Messrs. Chamberlain and Hookham are the contractors.

HERMOSAND, SWEDEN.—It was announced some time since that this town was to be lit by a Thomson-Houston plant driven by water-power. The installation is now an accomplished fact. The machines are placed at a distance of 2½ miles from the town, and supply 27 arc lamps of 1,200 candles each. This is found to be amply sufficient to light the whole of the streets of the town, which has only 4,000 inhabitants. The cost of the whole installation has amounted to about £1,150, and the annual expenditure is estimated not to exceed £100; giving an economy of 25 per cent. over the method of illumination previously in use.

ELECTRIC TRAMWAY IN PARIS.—An electric tramcar, expressly constructed for service between the Palace de l'Industrie and the Place de la Concorde during the Exhibition of Sciences and Industrial Arts, has recently been sent from Brussels to the French capital. The car was built by the Société l'Electrique, and will be propelled by an electric motor, fed by a battery of accumulators of the Julien type. The line on which it is to be run has been finished some time, so that it will be put into immediate operation. After having done duty at the Exhibition the car will return to Brussels, where it will be employed on the line in the Leopold quarter.

AN OVERSIGHT.—At Appleton, Wisconsin, on the day of the first public trial of the electric tramway, which has just been completed in that town, the electrician in charge had a distinct *mauvaise quatre d'heure*. The car was crowded with passengers, the road was *en fête*, the dynamo was running full speed, but when the motor was switched on nothing further occurred. The more ill-bred Appletonians raised a shout of derision, and it was not until every possible fault had been searched for that it was finally discovered that the dynamo was running without any brushes. The incident suggests a lamentable ignorance of the use of ammeters and voltmeters.

THE MEMORIAL TO THE LATE POSTMASTER-GENERAL.—The clay model of a colossal statue of the late Mr. Fawcett has been completed by Mr. Pinker, of Kensington, ready for casting in bronze for the memorial at Salisbury. The figure is standing without any adjunct as a support, and is most easily and naturally posed. The likeness of the face is admirable, and the slight stoop and other familiar details of the figure have been most truthfully rendered. Around the bronze base of the statue there will be an incised inscription, "The Right Honourable Henry Fawcett, Professor of Political Economy at Cambridge." The casting will be performed by Mr. Moore, of Thames Ditton.

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CURIOUS EFFECT OF LIGHTNING.—Although in this country we have had very few thunderstorms during the present summer, the Continental and American journals are full of accounts of severe storms and strange freaks played by lightning. Of this latter variety one of the most curious which we have met with is the following :—"During a thunderstorm at Plainfield, N.Y., a young lady lifted a lacquered metal tray which was lying on a table in front of the window. At this moment a blinding flash of lightning caused her to throw it hastily down. The next morning on examining the tray it was seen to bear an excellent profile likeness of the young lady apparently burned into the metal. The tray is to be placed in a public museum."

THE BRITISH MUSEUM.—The lighting of the Reading Room of the British Museum by electricity for the autumn and winter season began on Tuesday, the closing hour for readers being extended till 8 p.m. Mr. Barrett, the electrical engineer of the establishment, has been able to make considerable improvements on the lighting of previous years. It has been found that, from the great height of the dome and the large circumference of the room, four lights are not sufficient, and it has been considered necessary to add a fifth. Additional lights have also been placed in several of the galleries and in the new or "White" newspaper reading room, and the number of incandescent lamps throughout the building has been largely increased.

FINSBURY TECHNICAL COLLEGE.—We have received a copy of the programme of the Finsbury Technical College for the ensuing session. We would call the particular attention of those upon whose behalf the arrangements have been made to the special evening classes in electrical engineering "for apprentices and others engaged in electric lighting, telephony, electro-plating, and other branches of electric engineering." A student who diligently follows up this three years' course ought at the end of that period to find himself fairly on the way to becoming a thoroughly well equipped electrician. The fees for this course of instruction are extremely moderate, and a further reduction of 50 per cent. is made in the case of apprentices.

ELECTRICITY APPLIED TO FARRIERY.—General Boulanger has recently ordered the trial of a method of inducing vicious and restive horses to stand quietly while being shod. The method is due to the knowledge and ingenuity of M. le Capitaine Place, and is said to have proved eminently successful. We confess that such is our own ignorance of the electrical pathology of the noble quadruped that we should rather have expected the very opposite results to follow. The arrangement merely consists of an induction coil, a dry battery, and an arrangement for giving "a shock of graduated intensity" to the animal under treatment. The most vicious horses which could be found in the cavalry school at Saumur subsided into quietness upon the application of this device.

GAS V. ELECTRICITY.—The shareholders of the Eastbourne Gas Company are to be congratulated. Their Chairman (Dr. G. A. Jeffrey), in moving the adoption of the directors' report at the half yearly meeting last week, was able to announce an increase of 7¾ per cent. in the consumption of gas. The illuminating power of the gas now supplied stands at 16·1 candles, whereas the Act of Parliament does not require them to give more than 14 candles. This disinterested mark of generosity on the part of the gas company must be greatly appreciated by the inhabitants. The doctor explained that "the particular reason why this extra lighting power was given was to show the public the absence of any necessity to go to the Electric Light Company ; and he thought they had been paid for the experiment by having been called upon to make more and more gas every year."

EARTHQUAKES.—On August 27 a severe earthquake occurred in Greece by which several small towns and villages were destroyed. On August 31, about 10 p.m., an earthquake wave passed over the United States ; the shock was experienced with greater or less intensity over the whole of the country lying to the east of the Mississippi. The centre of the disturbance appears to have been situated in South Carolina, where the town of Charleston has been almost entirely destroyed. The Signal Service Bureau at Washington reports that four distinct shocks were felt at that place ; the first began at 9:54 p.m. and lasted 40 seconds, the second occurred at 10 p.m., the third at 10:10 p.m., and the fourth at 10:30 p.m. On the same night, between 10 p.m. and 12 p.m., several smart shocks were felt at Smyrna. A hill upon a small island lying off Sardinia is reported to have broken into volcanic eruption.

THE FIRST ELECTRIC LIGHT IN LONDON.—Mr. John Hollingshead, who has been identified with the management of the Gaiety Theatre since it was first opened about eighteen years ago, in severing his connection with that popular place of entertainment, concludes his farewell address by claiming to have achieved three things in the interests of the playgoing community, namely, the abolition of fees, the invention of *matinées*, and the introduction into London of the electric light. Our readers cannot fail to remember that it was at the door of the Gaiety where the first attempt to use electricity as an illuminant was made, nor can they forget with what varying opinions it was received by the public. It was an arc lamp installation on the Lontin system, and for a time, notwithstanding that it was remarkable chiefly for the unsteadiness of its light, it was regarded as one of the wonders of the metropolis.

THE PHONOPLEX SYSTEM OF TELEGRAPHY.—The system of duplex telegraphy which Edison has introduced under the title of "phonoplex" has met with much favour from the American telegraph companies, and has already received an extensive application. The Kansas and Southern Railway, the Sante Fé Railway, the Baltimore and Ohio Telegraph Company, and the Great North-Western Company of Canada, are all employing the system upon a large scale. Our readers are already aware that the system consists essentially in the employment of sounders, which are really Bell telephones of special construction, and which are connected upon the circuit through condensers, so that they only respond to induced currents. Currents of lower tension can therefore, at the same time and upon the same line, be employed for working ordinary Morse sounders. In fact, the system is developed upon precisely similar lines to that of the Rysselberghe system of working telephones and telegraphs simultaneously.

FATAL DISCHARGE OF GLOBULAR LIGHTING.—On the 9th inst. at Crawforth, Indiana, during the fall of a slight shower of rain, but in the absence of any indication of a thunderstorm, a ball of fire was seen to enter the window of a house occupied by one of the most prominent citizens of the town. Shortly afterwards, Mr. Riley was discovered lying upon the floor, his body, according to the American account from which we quote, burnt almost to a cinder and unrecognisable. A black streak was traced upon the carpet from the window to the fireplace, in which line the body was found. The family, who were sitting outside the house, witnessed the ball of fire enter the window and apparently disappear up the chimney. This is the second instance which we have recently recorded of a discharge of globular lighting having *ascended* a chimney. The fact would

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seem to indicate the possibility that its course may be determined in part by the direction of a current of air. But if, as we recently suggested, the phenomena is due to a small quantity of vapour charged to an excessively high electric tension, it is difficult to understand how it could continue its course after having discharged sufficient electricity to carbonise a human body.

THE OLDEST INSTALLATION IN EXISTENCE.—It is said that the Paris Hippodrome claims the honour of having been lit by electricity for the longest consecutive period on record. The installation dates back to the year 1877, when four "Serrin regulators" were first permanently installed. Each of these lamps was supplied from a separate Gramme dynamo in the manner then practised. From time to time the number of arcs has been increased, but, strange to say, the primitive arrangements have not only been retained but positively extended, so that at the present time there are no less than *seventeen* "Serrin regulators," each with its separate and distinct Gramme machine! These arcs do not, however, by any means represent the entire installation. There are employed in addition 133 Jablochkoff candles and over 1,000 incandescents. The current for the Jablochkoffs is supplied by seven alternating Grammes, for which four exciters are employed. Three additional direct current Grammes supply a portion of the incandescents, and the remainder are provided for by two Edison machines, each supplying 400 8 c.-p. lamps at 110 volts. The total number of dynamos is thus no less than thirty-three. All these machines are driven from one counter-shaft by cotton belting; the counter-shaft is driven in turn by two engines running at 180 revolutions. The machines are mounted on sliding frames, provided with screw adjustment.

AN ELECTRIC TRAVELLING CRANE.—An electric travelling crane is now at work at the warehouses of the Compagnie des Entrepos et Magasins Généraux, at Roabuix, France. At these warehouses the cotton bales, arriving mostly from America and La Plata, are stored before being forwarded to the different cotton mills. On account of the great fire risk, no steam crane is allowed in the establishment, and the bales, which weigh about half a ton each, had until recently to be hoisted and handled generally by manual labour. This work is now accomplished by a travelling crane worked electrically. The crane post is placed on a trolly which runs on rails, and a rail fixed to the ceiling of the warehouse guides the upper end of the post. The jib of the crane has a derrick motion. A small Gramme 4 horse-power dynamo is fixed on the trolly. This is always kept running (900 revolutions per minute), and being connected with suitable gearing, it can be made to hoist the load, advance the crane on the rails, and operate the jib. The current of 15 amperes, with an electromotive force of 250 volts, is conveyed to the crane by overhead sliding contacts from the generator, which is a 6 horse-power Gramme dynamo, running at 1,200 revolutions per minute. The commercial efficiency of this arrangement is stated to be 60 per cent. It shows, however, an economy in working, for, whereas formerly 10 men were required to handle 150 bales in 18 or 20 hours, now with this electric crane 4 men can do the same amount of work in 3 hours.

ELECTRIC LIGHT BUILDING BURNED.—The *Electrical Review* of New York reports that the large Brush station at 202 to 210, Elizabeth-street, New York City, supplying over 800 arc lights, has been almost entirely destroyed by fire. The fire began on the second floor of the three-story building, and is supposed to have been caused by a shaft heated at the journal from friction. In four minutes from the time of the first alarm at 7:28 o'clock the entire three-story building was in flames. The ten boilers, engines of a capacity up to 180 horse-power, and the 40 dynamos or generators were the costly part of the plant, which was valued in the aggregate at $200,000, and the loss will amount probably to $150,000, all covered by insurance. The West Twenty-fifth-street Station was still serving 400 lights between Fifty Ninth and Fourteenth-streets when the firemen got to Elizabeth-street. At the outbreak of the fire the electric light men connected the eastern system with the western by a switch at the Bowery and Fifth-street, but the firemen feared that in their wet clothing they would be in danger at their work with the wires alive, and orders were telephoned up to Twenty-fifth-street to shut down altogether, and the 1,200 lights were extinct. At midnight all the lights were burning again except the west head lights in Madison and Union Squares. The chief engineer says that the company can supply all the light from the west side station alone. The offices of the parent company—the Brush-Swan Electric Light Company of New England—were in the building that was burned.

A FRAUD.—The following American story comes to us through the columns of the *Etoile Belge*. It appears that two citizens of New York, both well known in Wall-street, recently announced that they were in possession of a new long-distance telephone, capable of speaking over any required length of line, overhead, underground, or even submarine. As a mere preliminary demonstration they were already prepared to exhibit its performance upon a line between New York and Chicago, and they had commenced negotiations for laying down a cable to be worked by their apparatus between San Francisco, Melbourne, and Pekin. This announcement created great excitement amongst *les gogos* (Anglicé, the greenhorns). They all rushed to the office in Broad-street to try the instrument. The articulation was found to be perfectly distinct and clear. Moreover, the information obtained from Chicago was verified by the telegraph lines. A large proportion of the proposed capital of $200,000 was rapidly subscribed, and the 10 per cent. due on application was promptly paid up. It then became necessary for the two promoters to visit Chicago in person. As they did not return so soon as was anticipated, it occurred to some curious individual to follow up the wire from the Broad-street office. It was then discovered that the line had not been quite completed through to Chicago, in fact, its total length did not exceed 98ft. At this end arrangements had been made to place the operator in rapid telegraphic communication with Chicago. Hence the accuracy of the intellegence, the excellence of the articulation, and the dismay of the gulls.

THE VAN DEPOELE ELECTRIC RAILWAY.—The following details concerning the Van Depoele system of electric railway are taken from an article in the *Electrical World*:—The system was first brought into practical operation at Chicago at the end of 1882. The current was conveyed by an overhead wire. No further details are given with regard to this early attempt. Two years later a line was opened at Toronto to connect the extremity of the street railway with the grounds of the exhibition there being held. On this occasion underground conductors were employed in the first instance, but afterwards these were replaced by an overhead cable. The line proved a decided success; three cars, carrying about 230 passengers, were drawn by each motor, at a speed of 30 miles an hour. A forty arc light dynamo was used, driven by a Doty engine, for which rather less than half a ton of coal was burnt per day. Experiments have since been made upon the South Bend Railway in the vicinity of Toronto, and it is in contemplation to work this line entirely by electric

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power. At the New Orleans Exhibition a train consisting of three cars was run with great success. At Minneapolis the Lydale and Minnetonka Railway Company have adopted the Van Depoele system for that portion of their line which runs into the city of Minneapolis. Forty-eight trains are run each way daily. A total weight of 91 tons has been hauled up an incline of 1 in 30 without difficulty. An old slide valve engine, 12 by 18 cylinder, making 125 revolutions per minute, is employed, and the consumption of coal is about 3,000lb. for seventeen hours run. The current is conveyed to the conductors by an overhead cable. Installations of very similar character are at work at Montgomery, Alaska, and at Windsor, Ontario. At three other towns in the States the system will very shortly be in operation, and further contracts are in the hands of the company.

VOTING BY ELECTRICITY.—At the mechanical exhibition at the Palais de l'Industrie in Paris there is exhibited a machine for registering votes which will, it is said, be shortly installed in the Senate and the Chamber of Deputies. Its object is to obviate mistakes, the loss of time, and the necessity of the members leaving their desks to record their votes. The machine, which is the invention of M. Debayeux, is worked by electricity, and the vote of a full house, it is said, may be made known by this means in less than five minutes. The arrangement of the apparatus is as follows :—In front of each seat three contact makers are placed, the knobs being marked respectively "Yes," "No," and "Abstention." Only one of the pushes can be depressed at one time, and neither of them can be used more than once until they have been released by the action of another part of the apparatus, which is under the control of the president. The voting is recorded by means of three sets of cylinders, upon which are inscribed in relief the names of the members in alphabetical order, and also the series of figures from 1 up to the total number of members. These cylinders rotate under inking pads, and after the voting, an impression being taken on a band of paper, against the name of each member present is found a number in one or other of the three columns "Yes," "No," or "Abstention." These numbers appear perpendicularly in numerical order. Hence the total number in each division is read at the foot of the three columns. The apparatus is necessarily somewhat complicated, but it is said to work with great facility. It will be noticed, however, that it can only be employed under the condition that each member always occupies the same seat. But for this difficulty it would be well worthy of the attention of our own Parliament, where a division seldom takes less than 20 minutes. We fear, however, that the facilities for "personation" which would necessarily result would sometimes prove a great temptation to some of our more frivolous legislators.

NEW METHOD FOR DETERMINING THE VERTICAL INTENSITY OF A MAGNETIC FIELD.—In the last number of *Wiedemann's Annalen* Herr Krüger describes a new method for determining the vertical intensity of a magnetic field. He points out that the methods hitherto used for measuring the vertical intensity of a magnetic field depend on the electromotive action which it exerts on a spiral which rotates about a horizontal axis. If, moreover, the spiral turns about a vertical axis, the ratio of the currents induced in the two rotations gives the inclination of the magnetic lines of force to the horizon. If, again, the current induced by a rotation about a horizontal axis be determined in absolute measure by a galvanometer, the vertical intensity of the field is determined from the contents of the surface enclosed by the windings of the spiral, and from the absolute resistance of the circuit formed by the spiral and the galvanometer. In a field of small extent the rotation must be replaced by a parallel displacement of the spiral in its plane. In any case the determination of a vertical intensity by these means is a difficult and tedious operation. In contrast with this, the deflection which a disc suspended horizontally by means of a vertical wire in a solution of copper sulphate experiences when traversed in a radial direction by a current, forms a very convenient means of determining the vertical magnetic force which produces that deflection. In order to test the capability of this method, it was used to determine the vertical intensity of the terrestrial magnetism, or rather the magnetic inclination. The value of the vertical intensity was thus found to be $V = 2{\cdot}2903 \times T$, in which T is the horizontal intensity. Simultaneous observations with the terrestrial inductor gave $V = 2{\cdot}2899 \times T$; while the vertical intensity deduced from the formula for variations given by Prof. Schering would be $V = 2{\cdot}2895\ T$. Taking as a mean $V = 2{\cdot}2899\ T$, it will be seen that the divergence obtained by this method does not exceed $\frac{1}{5700}$. The rest of the paper contains the establishment of the formula, and the experimental details and data.

A NEW SPEED COUNTER WITHOUT MECHANICAL CONNECTION.—We recently described a method by which M. Marcel Deprez proposed to count the number of oscillations made by a pendulum during any given time without in any way interfering with the freedom of the vibration. At the last meeting of the Académie des Sciences M. Gustave Hermite presented a note upon a somewhat similar subject. He proposes to determine the speed of a revolving body without touching it. The method is highly ingenious and interesting; but we doubt whether it is capable of any practical application even as a laboratory process. M. Hermite proposed to illuminate a disc attached to the revolving body by light from a Geissler tube. The tube is placed in circuit with a Rhumkorff coil arranged so that the number of makes and breaks per second is absolutely constant. The method of determining the number of vibrations of the hammer will be described immediately; for the present consider this number to be known. The disc, which is attached to the revolving body, and which is preferably connected so as to rotate in its own plane, is covered with paper on which some words have been printed—any printed paper will do. Now, it will be evident that if the number of illuminations of the tube per second is exactly coincident with the number of revolutions of the disc, the latter will appear to be at rest, and from some one position around the periphery of the disc the words upon the paper will be easily read; provided, however, that the speed of revolution is not less than about three turns per second. It is also evident that if the two motions be not absolutely synchronous the disc will appear to revolve more or less slowly in a direction, depending upon which of the two motions is the more rapid. Further, if the disc make precisely n times as many revolutions per second as the hammer makes vibrations, then a legible view of the printed surface will be attained, "right side up," at n different points around the circumference of the disc. It is thus necessary that the ratio between the rate of vibrations of the hammer and that of the revolutions of the disc should be represented by some integral number. On this point M. Hermite does not appear to have made any further suggestion. In any case it is necessary also to know the rate of vibration of the hammer. M. Hermite proposes to obtain this, as he says, "once for all," by comparison with a disc rotating at a known rate. The speed could no doubt be determined in this way; but from the considerations which we have just advanced we fail to see how this would serve the purpose "once for all."

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CONTEMPORARY PROGRESS.*

ON THE LAW OF THE ELECTRO-MAGNET AND THE LAW OF THE DYNAMO.

By S. P. Thompson, in *Philosophical Magazine*, 5th Series, Vol. XXI., 1886.

The author comments on the want of agreement among physicists as to the true law of the electro-magnet, and points out that most of the mathematical formulæ which have been given are not at all in accord with experiment, and are mostly based on no consistent theory. The relations determined by Weber ("Electrodynamische Maasbestimmungen," p. 572) between the magnetising force and the induced magnetism are an exception to this, but his expressions are very unmanageable.

The expressions generally given in treatises on physics are

Lenz and Jacobi's formula, $M = K S i$,

where i is the strength of the current in the coil, S the number of turns in it, K a constant depending on shape and quality of iron, and M the strength of the pole;

and *Müller's formula*, $m = b \tan^{-1} \frac{S i}{a}$,

where a and b are constants depending on the form, quantity, and quality of the core, and the form and disposition of the coils.

Both of these are empirical, and do not agree with experimental results. The discovery of the true law and its expression in a simple form is of great importance, as upon it the determination of the law of the dynamo depends.

A law which agrees well with experiment is now known, chiefly as the result of Frölich's researches, published mostly in the *Electrotechnische Zeitschrift* (Vol. II., 1881), and subsequent volumes, with the exception of the first, which is published in the *Berl. Berichte*, 1880, p. 978. Following Faraday's law of induction, Frölich assumes that the induced electromotive force E will be proportional to the speed of the machine n, and to a quantity, M, which he calls the "effective magnetism," and which is itself proportional to the effective area of the armature coils and to the intensity of the magnetic field.

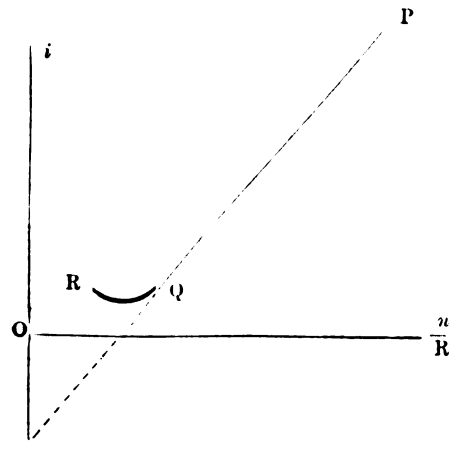
This gives $E = n M$;

but, by Ohm's law, $E = \frac{i}{R}$.

Therefore, $\frac{i}{M} = \frac{n}{R}$.

Since M is a function of i, and not primarily of n or R, it follows that i is a function of $\frac{n}{R}$, so we may write $n/R = \phi(i)$.

This function Frölich endeavoured to determine experimentally by observing the values of i for different values of n and R, and plotting the results as a curve obtained by taking the values of i as ordinates, and the values of n/R as abscissæ.



This curve, which he calls the "current curve," is found to be, with the exception of the part near the origin, sensibly a straight line not passing through the origin. The observations for the curved portion are difficult to make, as they depend either on values of n so small, or values of R so great, that the dynamo can scarcely excite its magnets. The straight line, therefore, is the only part of the curve applicable to practical conditions of use of the machine, so that we may write, where a and b are constants,

$$b i = \frac{n}{R} - a,$$

giving as the equation of the series dynamo

$$i = \frac{1}{b}\left(\frac{n}{R} - a\right).$$

The expression for M will therefore be,

$$M = \frac{i}{a + b i}.$$

In 1883 the author had been using the fundamental law

$$E = 4 n A H$$

to express the average value of the electromotive force developed by rotating an armature of total effective area A in a uniform magnetic field of intensity H, and requiring a formula to connect H with the exciting current he noticed that Frölich's formula gave what was needed, and finding it necessary for compound-wound machines to express the excitation in terms of ampere-turns rather than those of amperes, he wrote the formula

$$H = G S i \frac{k}{1 + \sigma S i},$$

where $S i$ is the number of ampere-turns, G a geometrical coefficient, k the coefficient of magnetic permeability in the initial stage, and σ a small saturation coefficient depending on the quantity, quality, and form of the core.

Writing $Z i_s$, the number of ampere-turns in a shunt-winding, in place of $S i$ in the above formula, we get the corresponding formula for shunt-wound machines, and for compound-wound machines we get

$$H = G (S i \pm Z i_s) \frac{k}{1 + \sigma (S i \pm Z i_s)}$$

Inserting these valves in the fundamental equation, and writing e for the difference of potentials at the terminals of the machine, and r_a, r_m, r_s, and R for the resistances of the armature, main circuit-coil, shunt-coil, and external circuit respectively, we get

For Series Dynamo—

$$E = \frac{1}{\sigma}\left\{4 n A G k - \frac{\Sigma R}{S}\right\}$$

For Shunt Dynamo—

$$E = \frac{1}{\sigma}\left\{4 n A G k - \frac{r_a r_s + R r_s + R r_a}{Z R}\right\}$$

For Compound Dynamos (at critical speed for regulation)—

$$e = \frac{1}{\sigma}\left\{\frac{r_s (r_a + r_m)}{S (r_s + r_a)} - \frac{r_s}{Z}\right\} \text{ (short shunt.)}$$

$$e = \frac{1}{\sigma}\left\{\frac{r_s (r_a + r_m)}{S (r_s + r_a + r_m)} - \frac{r_s}{Z + S}\right\} \text{ (long shunt.)}$$

These formulæ are given in the author's volume on "Dynamo-Electric Machinery," where he also shows that $\frac{1}{\sigma}$, which he calls the *determinant* of the working power of the dynamo, is that number of ampere turns which will reduce the effective permeability of the electro-magnet, or rather of the magnetic circuit, to half its initial value.

n	R	e obs.	e calc.	i obs.	i calc.
850	0·841	127	127	151·0	151·0
853	1·22	133	133	109·0	109·0
855	2·34	139	140	59·9	59·4
850	4·52	138	139	30·3	30·5
850	9·25	136	138	14·7	14·7
850	22·1	137	136	6·2	6·2
845	222·0	133	134	0·6	0·6

* Compiled and translated by G. W. de Tunzelmann.

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The preceding table gives the result of some experimental comparisons made by Frölich of results obtained from his formula with those obtained experimentally.

Now, Lamont, in his "Handbuch von dem Magnetismus" (1867), p. 41, gave the equation

$$m = \frac{a\,\mathrm{M}\,x}{\mathrm{M} + a\,x}$$

(when x = magnetising force, m = induced magnetism, M = maximum value of m) as a convenient first approximation to another equation, based on a new theory of induced magnetism.

Writing G k for a, S i for x, and σ for a/M, we get

$$m = \frac{\mathrm{G}\,k\,\mathrm{S}\,i}{1 + \sigma\,\mathrm{S}\,i},$$

the author's way of uniting Frölich's equation.

Lamont's physical theory has since been revived independently in a more elaborate form by Bosanquet (*Phil. Mag.*, Series V., Vol. XIX., p. 85, 1885)—Lamont's theory assumes that for any bar there is a maximum value of the magnetisation, and that at every stage of the magnetisation the permeability is proportional to the deficit from this maximum, which gives for the permeability $d\,m/d\,x$,

$$\frac{d\,m}{d\,x} = k\,(\mathrm{M} - m)$$

which gives, since m and x vanish together,

$$m = \mathrm{M}\,(1 - \Sigma^{-k\,x}),$$

which may be developed in the form

$$m = \mathrm{M}\,k\,x\left(1 - \frac{k\,x}{1\cdot 2} + \frac{k^2 x^2}{1\cdot 2\cdot 3} - \ldots\right),$$

which Lamont remarks may be approximately represented by the simple but empirical expression,

$$m = \frac{a\,\mathrm{M}\,x}{\mathrm{M} + a\,x},$$

for writing $k = a/\mathrm{M}$, and developing in ascending powers of $k\,x$, we get

$$m = \mathrm{M}\,k\,x\,(1 - k\,x + k^2 x^2 - \ldots),$$

so that the two expressions give nearly the same result for small values of $k\,x$.

None of these formulæ take account of the concavity often found in the early part of the curve of magnetisation, due to an increase in the permeability after a certain stage of magnetisation has been reached; but this is of no practical importance, since the apparent maximum of permeability is attained in most cases at a much lower degree of magnetisation than that at which the dynamo is actually worked.

The experimental comparisons show that Frölich's formula may be taken as something more than a first approximation to the true law of the electro-magnet within the limits of saturation occurring in practice, and it may be taken as a first approximation for all degrees of saturation beyond those usually attained.

ON THE BEHAVIOUR OF ROCK-CRYSTAL IN A MAGNETIC FIELD.

By O. Tumlirz, in *Wiedemann's Annalen*, Vol. XXVII., 1886.

The behaviour of quartz in the magnetic field was studied by Plücker in several researches (*Pogg. Ann.*, Vols. LXXII., 1847; LXXVIII., 1849; and LXXXI., 1850), but the results obtained were so discordant that he came to the conclusion that the action observed was due entirely to particles of iron accidentally present. The subject was also taken up by Knoblauch and Tyndall (*Pogg. Ann.*, Vol. LXXXI., 1850), who at first got nothing but contradictory results; but finally, by taking special precautions to ensure purity in the crystal, and suspending it with extreme care, they succeeded in obtaining a series of ten observations which all agreed in showing a tendency in the crystal to set itself with its axis at right angles to the lines of force.

The author used in his experiments two plates of quartz cut perpendicularly to the optical axis, one left-handed and the other right-handed, about 4mm. in thickness, and about 25mm. long. The plates were carefully cleaned, washed repeatedly in alcohol, and finally soaked for 30 hours in weak hydrochloric acid. They were suspended by silk fibres, attached by knotted loops, and the greatest care was taken while attaching the fibres to ensure perfect cleanliness of the hands and of the material on which the plates rested.

In the first experiment a single pointed pole-piece was made to act on one or other of the plates placed equatorially, with the result that the part nearest to the pole was repelled in each case, showing that quartz, whether right-handed or left-handed, is diamagnetic.

Immediately after this the plates were successively suspended between the two poles, perpendicularly to the line joining them. On closing the circuit, the principal axis in each case moved from an axial to an equatorial position, and came to rest in a position making an angle of about 20deg. with the line joining the poles. On reversing the current the principal axis assumed a symmetrical position with respect to this line.

The last result can be observed still better in a uniform magnetic field. In order that the plate should take up its position of equilibrium with the circuit open, more rapidly, a bifilar suspension with a small restoring moment was used, and it was suspended with its principal axis perpendicular to the direction of the magnetic force. On closing the circuit the axis came to rest at an angle of about 60deg. with this direction, and on reversing the current it assumed a symmetrical position with regard to it.

These experiments were frequently repeated, always with the same results. The plates were found to have a permanent polarity due to induction, and if left suspended for several days with no iron near, the principal axes were found to take up a position perpendicular to the lines of force, as observed by Tyndall and Knoblauch, and by Plücker in his first research.

When the plate was subjected to magnetic action, either parallel or perpendicular to its axis, and was then suspended in a field of force, it was found to deviate more or less according to the intensity of its magnetisation and of the field.

Contrary to what would have been expected, since quartz is diamagnetic, the side opposite to the North Pole during the magnetisation was in each case attracted by it, and repelled by the South Pole. This result is in agreement with Becquerel's theory, according to which all bodies are magnetic, and diamagnetism is due simply to the greater magnetic permeability of the surrounding medium.

ON THE DOUBLE REFRACTION OF LIGHT IN METALLIC FILMS, Obtained by the Pulverisation of a Cathode.

By A. Kundt, *in Wiedemann's Annalen*, Vol. XXVII, 1886.

In his researches on the electro-magnetic rotation of the plane of polarisation of light the author had previously obtained thin transparent metallic films of iron, cobalt, and nickel, by electro-deposition on a thin layer of platinum burnt into plate glass. A difficulty was found in getting a perfectly uniform and coherent film of platinum, and another objection to the use of the platinum film was that it absorbed a sensible portion of the light which traversed the glass.

Now, Wright found (*Silliman's Journal*, January and September, 1877) that if strong electric discharges be passed through a Geissler tube, the metal forming the negative electrode becomes pulverised, and is deposited as a reflecting film upon the inside of the tube, and in this way he succeeded in obtaining thin films of different metals upon glass plates.

Kundt made use of the same apparatus as that employed by Wright. It consisted of a vertical cylinder about 10cm. in diameter, open at both ends, which could be closed when requisite by glass plates, to which vertical tubes were cemented. An aluminium electrode was fused into the lower of these, and the cathode, formed of the metal to be pulverised, was placed in the upper one. The latter was, for convenience of removal, fused into a narrower tube, and fixed in position by means of an india rubber cork. The glass plate on which a film was to be deposited was supported horizontally under the cathode by

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means of a glass tripod. The exhaustion was effected by means of a mercury air pump, and the electric discharges were obtained from a large induction coil worked by three to six Bunsen cells. Films, even of easily oxidisable metals, such as iron, could be obtained without difficulty by taking special precautions to exclude every trace of oxygen and water vapour, as Wright had already shown. The pulverisation was found to take place most rapidly and thoroughly when the cathode was at a red heat, but the best degree of exhaustion and strength of the discharge had to be determined for each metal. When examined under the microscope by transmitted light the films were found to be perfectly coherent and homogeneous. Newton's rings were generally seen, even when the films were apparently quite free from oxide. On placing them between two crossed Nicol's prisms the author was surprised to find that they were doubly refracting.

The phenomenon was observed with films of platinum, palladium, gold, silver, copper, and iron. When the cathode consisted of a straight wire perpendicular to the plate on which the film was to be formed, the metal was deposited in the form of a cone, with its vertex perpendicularly below the wire. When the conical film was placed between two crossed Nicol's prisms and observed by means of a beam of parallel light, a black cross was seen on a bright ground, having its arms in the planes of polarisation of the polariser and analyser respectively, and its middle point coinciding with the vertex of the cone.

It was shown that this appearance was not due to the conical form of the film by allowing polarised light to pass through the glass so as to fall nearly perpendicularly upon the plane surface of the film, and examining the reflected light by means of a second Nicol's prism placed crosswise to the first, when the same appearance was observed as before, even when the film was so thick as to be opaque. Experiments were also made which proved that the effect was not due to the glass, as it might have been supposed to be caused by a state of strain in the glass set up by cooling after being heated by the hot electrode just over the vertex of the cone.

It was also proved by various experiments that the double refraction was not due to a state of tension in the metallic film on cooling after being unequally heated.

The appearance even then might be due to a radial crystalline disposition of the particles of metal, provided each crystal were itself double refracting; but silver, gold, and copper crystallise according to the cubical system, and, as far as is known, are not dimorphous. The author therefore believes that the double refraction must be due to a special arrangement of the particles of metal under the action of electrical forces, which with the vertical wire cathode used would necessarily be symmetrical with regard to the point immediately below it, and therefore if double refraction were produced in that way it would be of the kind observed.

It was found that in the case of an easily oxidisable metal all traces of double refraction disappeared when the film was heated in contact with air. The author found no trace of double refraction in electrolytically-deposited films.

In the case of silver a variation was observed in the colour of different films when viewed by transmitted light, the colours varying from blue to reddish violet. How far these variations depend on the strength of the electrical discharge and the consequent variation in the temperature of the electrode, and on the nature of the gas in the tube, has not yet been determined.

ON THE DEFLECTION OF THE EQUIPOTENTIAL LINES AND The Variation in the Resistance of Bismuth in the Magnetic Field.

By A. Leduc (*Comptes Rendus*, Vol. CII., p. 358, Feb., 1886).

Variations in the Resistance of Bismuth.

The author used for his experiments a plate of bismuth 5·5cm. in length, 3·2cm. in breadth, and with a mean thickness, calculated from its resistance, of ·0233mm. The changes were studied both for variation in the temperature t, and the intensity M of the magnetic field. The results of a number of experiments were well represented by parabolic formulæ of the form—

$$\rho M = \rho_0 (1 + a M + b M^2 - c M^3) \quad (t \text{ constant}),$$
$$\rho t = \rho_0 (1 - p t + q t^2) \quad (M \text{ constant}),$$

where ρ_0 is the resistance of the plate per centimetre of its length when t and M are both zero.

The coefficients, a, b, c, p, q, were found to have the mean values—

$$a = 277 \times 10^{-8} \quad p = 303 \times 10^{-5}$$
$$b = 228 \times 10^{-11} \quad q = 188 \times 10^{-7}$$
$$c \times 105 \times 10^{-15}$$

and the value of ρ_0 was found to be ·0183.

Hall's Phenomenon.

Let A, B, G, H represent the middle points of the sides of the plate. Binding screws, fixed at A and B, served as electrodes for a current which traversed the plate longitudinally. Two other binding screws, fixed at G and H, but insulated from the metal by means of mica, carried small springs with rounded ends, which pressed upon the plates at two points, E and F, of the line G H.

Let D be the deflection of the equipotential line passing through the point E in a magnetic field of intensity M at the temperature t, ρ the resistance of the plate per centrimetre of its length under the same conditions, I the strength of the current, d the distance E F.

Between these two points a difference of potential will be maintained, given by the formula

$$e = I \rho d \tan D.$$

The angle D was found to be never greater than 5° in the experiments, and therefore D may be written for tan D.

If we assume that the variations in the resistance with M and t respectively are independent, and writing

$$\phi(M, t) = (1 + a M + b M^2 - c M^3)(1 - p t + q t^2) = \delta = \frac{e}{I \rho_0 d};$$

we shall therefore have

$$D = \frac{e}{I \rho d} = \frac{e}{I \rho_0 d \phi(M, t)} = \frac{\delta}{\phi(M, t)}$$

It only remains then to investigate the function.

Three sets of experiments were made to determine the effect of M, t, and I respectively. The relation between e/I and M were found to be given by the equation

$$\frac{e}{I} = \mu M (1 - \alpha M + \beta M^2)$$

where
$$\alpha = 91 \times 10^{-6}$$
$$\beta = 316 \times 10^{-11}$$

When M and t were maintained constant as far as possible, D was found to be independent of I.

The temperature was made to vary between 0° and 70°, and the change in δ was found to be given by the formula

$$\delta = \delta_0 (1 + m t - n t^2),$$

where
$$m = ·00541$$
$$n = ·000093.$$

We get then

$$\delta = K M (1 - \alpha M + \beta M^2)(1 + m t - n t^2),$$

and therefore

$$D = K M (1 - A M + B M^2 + C M^3)(1 + P t - Q t^2),$$

where
$$K = 158 \times 10^{-7}$$
$$A = a + \alpha = 882 \times 10^{-7}$$
$$B = \beta - b + a A = 112 \times 10^{-11}$$
$$C = c + b A - a B = 303 \times 10^{-15}$$
$$P = m + p = 844 \times 10^{-5}$$
$$Q = n + q - p P = 862 \times 10^{-7}$$

It is easily seen that D reaches about 5° in a field of intensity 10,000 C.-G.-S. D is a maximum at the temperature 49°. As the resistance of bismuth increases more than 15 per cent. in a magnetic field of 10,000 C.-G.-S., the author intends to make use of this variation, when fully investigated, to measure magnetic intensities.

This increase in the resistance is partly due to the deflection of the equipotential lines, in fact the resistance must be multi-

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plied by 1/cos D; this coefficient, however, will not exceed 1·005, and therefore the explanation must be sought in the change in structure of the metal produced by the alteration in the electric field of the plate.

THE ELECTRO-MAGNETIC ROTATION OF ORDINARY LIGHT.

By L. Sohncke, in *Wiedemann's Annalen*, Vol. XXVII., 1886.

The object of the research was to endeavour to determine whether or not ordinary unpolarised light could be acted on by magnetic force.

It is known that two beams of plane-polarised light from the same source interfere more or less completely when they meet at a sufficiently acute angle, the interference being most complete when the planes of polarisation of the two beams are parallel, and ceasing entirely when the planes of polarisation are at right angles.

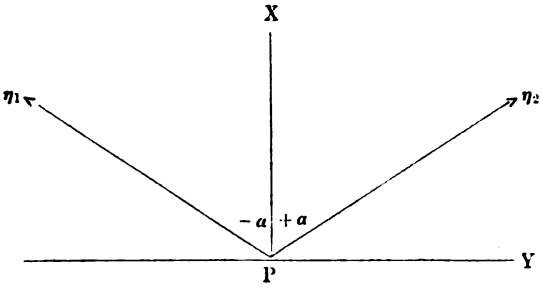
Pencils of ordinary unpolarised light proceeding from the same source interfere in exactly the same way as polarised pencils with their planes of polarisation parallel.

Now, ordinary light may be regarded as plane polarised light, in which the plane of polarisation passes through all possible positions within a very short period, and the interfering rays which cannot differ much in the length of their path may be regarded as polarised in parallel planes. If it be represented more generally as light polarised elliptically, with the major axis of the ellipse continually changing in position, the corresponding rectangular components of two interfering rays may still be regarded as being polarised in parallel planes.

It is clear, therefore, that if the direction of vibration with the first representation, or the major axis of the ellipse, with the second, of one of two mutually interfering rays, be rotated through an angle of 90° with regard to that of the other ray, the two rays will behave as though they were polarised in perpendicular planes. This gives a means of determining whether ordinary light is subject to the same electro-magnetic action as polarised light. The investigation was greatly facilitated by the results of some experiments of Prof. Abbe hitherto unpublished, which he communicated to the author.

Prof. Abbe found that when a slice of right-handed quartz, of such a thickness (1·88mm.) as to rotate the plane of polarisation of sodium light through 45°, was interposed in the path of one of two interfering rays, and a slice of left-handed quartz of equal thickness in the path of the other ray, the interference fringes disappear, not only in the case of polarised light, but also when ordinary light was used. When the experiment was repeated with slices of quartz of twice this thickness, so as to produce a rotation in each case of 90°, the fringes were again seen.

These results were important in connection with the author's investigations, as it enabled him, instead of endeavouring to produce an electro-magnetic rotation sufficient to cause a disappearance of the fringes, to cause the fringes to disappear by the introduction of slices of quartz, as in Prof. Abbe's experiments, and then to endeavour to produce their reappearance by electro-magnetic action, and therefore the experiments could be made with weaker currents and with thinner slices of the substance in which the electro-magnetic rotation was produced. The attention of the author was, therefore, in the first place directed to the further consideration of the phenomenon observed by Prof. Abbe.



Consider two rays of plane polarised light with their planes of polarisation rotated in opposite directions through angles $+\alpha$ and $-\alpha$ respectively, making so small an angle with each other that they may be treated as parallel, and meeting at the point P. Then they may both be supposed perpendicular to the plane of the paper, and the axis of X may be taken as the original direction of vibration. Let δ be the difference between the paths of the two rays measured from the screen to the point P, T the time of a complete oscillation, and λ the wave length of the light used. Then, if the amplitude of vibration be taken as unity, the distance η of a vibrating molecule at the time t from its position of rest P will be given in the case of the two rays respectively by the equations.

$$\eta_1 = \cos 2\pi \frac{t}{T};$$

$$\eta_2 = \cos 2\pi \left(\frac{t}{T} - \frac{\delta}{\lambda} \right),$$

and resolving along the axes these give the components

$$x_1 = \cos\alpha \cos 2\pi \frac{t}{T}$$

$$y_1 = -\sin\alpha \cos 2\pi \frac{t}{T}$$

and

$$x_2 = \cos\alpha \cos 2\pi \left(\frac{t}{T} - \frac{\delta}{\lambda} \right)$$

$$y_2 = \sin\alpha \cos 2\pi \left(\frac{t}{T} - \frac{\delta}{\lambda} \right)$$

giving a resultant vibration

$$x_1 + x_2 = \cos\alpha \left\{ \cos 2\pi \frac{t}{T} + \cos 2\pi \left(\frac{t}{T} - \frac{\delta}{\lambda} \right) \right\}$$

along the axis of x_1, and

$$y_1 + y_2 = \sin\alpha \left\{ -\cos 2\pi \frac{t}{T} + \cos 2\pi \left(\frac{t}{T} - \frac{\delta}{\lambda} \right) \right\}$$

along the axis of y, which may be written

$$x_1 + x_2 = X = 2\cos\alpha \cos\frac{\delta\pi}{\lambda} \cos 2\pi \left(\frac{t}{T} - \frac{\delta}{\lambda} \right)$$

$$y_1 + y_2 = Y = 2\sin\alpha \sin\frac{\delta\pi}{\lambda} \cos 2\pi \left(\frac{t}{T} - \frac{\delta - \frac{\lambda}{2}}{2\lambda} \right)$$

Now if a and b be the amplitudes of vibration of two rays, whose directions of vibrations are at right angles to each other, the resultant intensity T is given by the equation

$$J = \frac{2\pi^2}{T^2}(a^2 + b^2)$$

and therefore if J be the intensity at the point P

$$J = \frac{8\pi^2}{T^2} \left\{ \cos^2\alpha \cos^2\frac{\delta\pi}{\lambda} + \sin^2\alpha \sin^2\frac{\delta\pi}{\lambda} \right\}$$

If J_m be the intensity at the centre (where $\delta = 0$) and J_s the intensity at a distance from the centre, equal to half the distance between the fringes (where $\delta = \lambda/2$)

$$J_m = \frac{8\pi^2}{T^2} \cos^2\alpha;$$

$$J_s = \frac{8\pi^2}{T^2} \sin^2\alpha.$$

Then for $\alpha = 45°$,

$$J_m = J_s = \frac{4\pi^2}{T^2},$$

and the general expression for J gives the same value at every part of the field, which is therefore uniformly bright.

For $\alpha < 45°$, $J_m > J_s$, or the centre is the brightest portion, and fringes appear, which become more disturbed as α approaches 0, when $J_m = 8\pi^2/T^2$, and $J_s = 0$, so that the centre is as bright as possible, and the adjacent fringes are perfectly dark.

For $45° < \alpha < 135°$.

$J_m < J_s$, and therefore the centre is the darkest portion, and for $\alpha = 90°$ $J_m = 0$ and $J_s = 8\pi^2/T^2$, so that the centre is perfectly dark, and the adjacent fringes are as bright as possible. On either of the hypotheses already given for the constitution of ordinary light, these should be obtained with it, as well as with polarised light, and this was fully confirmed

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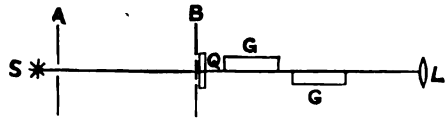
by experiment. The phenomena were observed almost as distinctly with white light as with homogeneous light, owing to the fact that in white light the other colours are of feeble intensity compared with the yellow.

Electro-magnetic Rotation Experiments.

The general management of the apparatus, without details of adjustment, is shown in the diagram.



The source of light was a gas flame, S, placed immediately behind a screen, A, through a narrow slit in which the light passed. The pencil of light so obtained fell upon a second screen, B, provided with two small slits, passed through the quartz Q, 1·88 mm. in thickness, which could be placed so that one slice should be in front of each slit, or the same slice in front of both slits, as required. The pencils then passed through two exactly equal and similar pieces of heavy glass G, consisting of pure silicate of lead, cut in such a manner from the same block, and so placed, that if one of the pieces was made to slide along the line S L, until the sides in contact with this line coincided, the two pieces would occupy the same relative position as in the original block. They were supported in such a way that they could be surrounded by coils of wire without disturbing their position. The interference fringes were observed by means of the lens L.

In making an observation, one slice of quartz was first made to cover both the slits in the screen B, and the apparatus adjusted so that the fringes were clearly defined.

The coils of wire were then placed in position round the pieces of glass G, G, and the separate slices of quartz were placed before the two slits, causing a complete disappearance of the fringes. A current of 20 amperes or upwards from a Shuckert compound dynamo was then sent through the coils in such a way as to cause opposite rotations in the two pieces of glass when the fringes again became visible, showing that ordinary light is subject to the same electro-magnetic action as polarised light. When the direction of the current was such as would have caused rotation in the opposite direction to that produced by the quartz in the case of polarised light, the fringes reappeared in their original position. When the direction of the current was reversed the fringes were displaced through half the distance between them, so that the dark bands were replaced by light ones, and *vice versâ*.

It is therefore clear from the analysis previously given that the electro-magnetic rotation of the direction of vibration of a ray of ordinary light is in the same direction as the current round the pieces of glass, as is the case for polarised light.

The observations had to be made quickly, and could not be frequently repeated without allowing some time to elapse, as the glass soon became heated owing to the heat developed in the coils by the passage of the currents, which therefore acquired temporarily the property of double refraction.

CORRESPONDENCE.

THE PROSPECTUS OF THE REGENT PORTABLE LAMP AND LIGHTING COMPANY (LIMITED).

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It is to the general interest of the public and the electric community that more capital should be invested in electric industry. We all know that it is possible to employ large amounts of capital, and at a profit, in electric work, but after the immense and needless retardation suffered by electric lighting a few years back through the careless knocking together of companies and bad management, all who have been identified with electric lighting from its commencement in this country have a right to jealously guard the interests of the public in this matter, and consequently their own, and I am sure that the technical journals devoted to electric work are earnestly determined to safeguard these interests so far as possible.

I should be sorry to say anything that would cause grievance to any inventor who may have worked long and hard, and be on the point of seeing his hopes and wishes realised, but the above prospectus involves the following observations:—

1st. Dr. Fleming, Mr. Sydney F. Walker, and Messrs. Ingrey, Poore, and Latham, all, of course, by having their names, reports, &c., in the prospectus, as they are, pledge themselves to the public on the points claimed by the prospectus.

2nd. It is claimed that the battery is "the invention of the century."

3rd. That numerous primary batteries have lately been introduced to the public, but none of them have been of any practical commercial use." Now, is this statement correct or not? What have Messrs. Johnson and Phillips to say to this? as it affects the battery which they largely advertise as a practical success. Would not Messrs. Woodhouse and Rawson dispute this statement, and Mr. Upland have something to say? Would not the Volta-Pavin battery, which is meeting, I believe, with considerable success in America, and is now being introduced here on a commercial footing, controvert this statement?

4th. One paragraph says: "The following are some of the *special* features in connection with electric lighting by means of this battery."

The public would surely understand this to mean features *peculiar* to the battery in question. The points mentioned under this heading are that "it is self-contained"; "that no machinery is required"; "the battery being very small and portable can be removed from house to house, &c."; "atmosphere not vitiated, &c."; "a steady and constant light is maintained 8 to 13 hours without attention."

If this latter point meets the view of the technical gentlemen concerned, they are very easy to please. The length of time a battery will run depends on the liquids used and the quantity, to a great extent; but batteries are now being made for house lighting that go from six to ten times the number of hours here mentioned without alteration. As regards Dr. Fleming's report, in his preliminary letter it is not clear whether he means that there is no local action in the battery or whether it is only got rid of to a remarkable degree. However, in his detailed report he says that the average loss by local action is $\frac{1}{4}$ per cent. per hour, but in one of his concluding paragraphs he says:—"One thing that greatly recommends such a primary battery as this for such domestic lighting is that it can be used occasionally whenever required. Now, no arrangement in which secondary cells are used can be employed intermittently." Now, if the battery is to be used intermittently (in practice for house lighting a battery will be idle, say, 18 hours out of 24 on an average), what will become of the plates which vanish at the rate of $\frac{1}{4}$ per cent. per hour, say, in one month?

How in this respect will the battery be superior to accumulators?

Does Dr. Fleming consider that the second clause of his table of requirements is met by this $\frac{1}{4}$ per cent. per hour? As regards the local action, which Dr. Fleming puts at $\frac{1}{4}$ per cent. per hour, in this same prospectus Messrs. Ingrey, Poore, and Latham state that "*entire* absence of local action is one of the astounding features of the invention."

Mr. Sydney F. Walker states that "this invention has rendered a practicable portable electrical miner's lamp possible for the first time."

He also says that the materials used are the cheapest known to science for this purpose. I think these statements are more glowing than easily supported. On the solution question, if he refers to the mixture described, but now claimed by Mr. Macquay, Mr. O. C. D. Ross could enlighten him.

We are all glad to see a New York electrical appliance to the fore, but would not the labours of those concerned in this matter have been more sure of reward if they had been dealt with on a different basis—as to points claimed, &c.?

What is it that Dr. Fleming, Mr. Sydney F. Walker, and Messrs. Ingrey, Poore, and Latham, by their position in this affair, as representing electrical experts, recommend the public to pay £45,000 for—£17,500 in cash?

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No particular solution is claimed in the battery. There are four claims :—

1st. Is for the alloy of mercury, tin, and lead (in the proportion stated) with zinc.

2nd. For a method of amalgamating.

3rd. Is for treating the carbon electrode with sulphur (painting the upper part, as I understand it).

4th. Is the arrangement of letting all the liquids intermix when filling the cells.

I must apologise for the length of these reviewing remarks, but I hope you will see there is ground for criticism in the real interest of electric work.—Yours, &c.,

RADCLIFFE WARD.

P.S.—I know a set of Volta-Pavin cells that run 240 hours. They had one solution changed about every 60 hours (four times).

10A, Great Queen-street, Westminster,
September 1, 1886.

DOMESTIC ELECTRIC LIGHTING.—A PROTEST.

TO THE EDITOR OF THE ELECTRICIAN.

SIR : We beg to refer to the prospectus of the Regent Portable Electric Lamp and Lighting Company (Limited) which is now being advertised, and subscriptions for shares in which are now being sought.

We beg to state that we are the owners of patents for domestic electric lighting produced by primary batteries which are both extensively in use and a great commercial success.

The statement in the prospectus of the Regent Portable Electric Lamp and Lighting Company (Limited) "that numerous primary batteries have lately been introduced to the public, but *none* of them have been of any practical or commercial use" is incorrect. For instance, we guarantee to run our batteries without discharging or any alteration whatever ten times the number of hours claimed for the Regent.

As the above statement in the Regent prospectus is calculated to do us great damage we shall be obliged if you will give publicity to this letter.—Yours, &c.,

JAMES S. BURROUGHES, Chairman.

The Loeb Chemical Electric Light Company (Limited),
19, Soho-square, W.

ABSOLUTE NEGATIVE CHARGES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR : I am pleased to gather from Mr. Caine's letter published last week that in his opinion the number is small of those who are ready to come forward to answer for the absolute negative charge, and that there are not many who believe in their heart and soul that the earth carries a negative charge, and that the corresponding positive charge is banished out of all localised existence in the universe, or, as it is expressed by mathematicians with their more refined conceptions, situated "at an infinite distance."

However, the chief bearing of your correspondent's remarks seems to be an objection to the use of the word "static" in connection with those electrical phenomena to which it is generally applied, and more particularly to the quoted expression "electrostatic circuit." Whilst I agree that the term "inductive circuit" is very appropriate, I do not feel that "electrostatic" is an unsuitable epithet. Electrostatics and static electricity, are these ill-chosen expressions? To me the statical phenomena of electricity seem quite the counterpart of the phenomena of mechanical statics.

I should be sorry if any of your readers were misled by Mr. Caine's reflections on what I said about strain and yielding, as well as about the action of a dielectric medium. Mental abstractions are the very essence of science, and we are constantly obliged to use the words "so far as" to indicate that we are considering one feature alone, and neglecting for the moment other aspects of the case before us. Thus, as a matter of fact, every dielectric does conduct a little and slowly; nevertheless, *qua* dielectric it does not conduct. The gradual leakage which a dielectric permits is not its principal and essential action, but an accident. Conduction is no part of induction so far as it is induction. And although Mr. Caine may often have heard the cracks and squeaks of a rope on the capstan, it is nevertheless true that strain, as such, is incompatible with yielding. The stretching of a rope is, I certainly think, a temporary hindrance to our setting up in it the desired tension.—Yours, &c.,

E. ALDRED WILLIAMS.

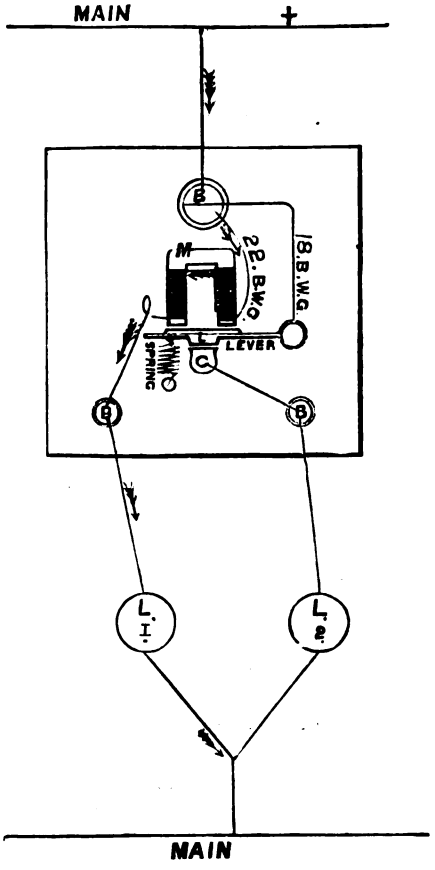
ELECTRICAL TRAIN LIGHTING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR : In your last week's issue I notice a paragraph relating to my "Improvements in Electrical Train Lighting" which states that there is only one lamp in each compartment.

There are two 16 candle-power 50-volt lamps in each compartment, but only one is lit at a time. By the introduction, however, of a special contact maker, the second lamp lights up on the first one giving way. I devised this so as to have another lamp ready in event of the first one breaking, and find it works very well when constructed and coupled up as shown on enclosed sketch.

As stated, the lamps are 50-volt ones, and are coupled in parallel. There is nothing special about the contact maker, except *arrangement of connections*, and I do not remember seeing anything so simple before.



B B B Binding screws ; C Contact maker ; L L Lamps ; M Electromagnet wound with eight layers of No. 22 B.W.G. wire.

If not new to you, perhaps its application may be so to some of your readers.

My name was wrongly spelt in the *Scotsman*.—Yours, &c.,

THOS. P. CARSWELL.

Edinburgh, August 27th, 1886.

[CORRESPONDENCE *continued on page 343.*]

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

All communications to be addressed to 1, *Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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THE BRITISH ASSOCIATION.

The meeting of the British Association this year at the centre of British industry bids fair to be as important and as interesting as that which was held there twenty-one years ago, under the presidency of JOHN PHILLIPS, one of the founders of the Association. In its choice of president for the coming year it has been peculiarly happy. Sir WILLIAM DAWSON is a man of world-wide reputation in the special branch of science to which he has devoted a lifetime; but he is also a Canadian; and at a time when greater Britain is being entertained in the metropolis, and when the desire for closer unity among her children is taking definite and practical shape in the mother country, the selection is naturally regarded as having some significance. Two years ago the Association held its meeting for the first time outside the British Isles; and in 1888 Australia will follow the example of Canada. No wonder that the present representative of Colonial science, from the presidential chair on Wednesday evening, referred to these striking facts as proof of the Imperial character of the Association, and the consolidation of the scientific interests of Her Majesty's dominions. The industrial gathering at South Kensington and the scientific union at Birmingham are pledges of a moral federation of the Empire which may perhaps be more enduring than any political federation we could devise, and is certainly beset with fewer practical difficulties.

Sir WILLIAM DAWSON'S presidential address, which we print elsewhere, was almost exclusively confined to a geological survey of the North Atlantic ocean, a subject with which as a specialist he was peculiarly competent to deal, and which he contrived to make as attractive as any special subject of the kind could possibly be. Setting himself the seemingly impossible task of answering such questions as, What has at first determined the position and form of the Atlantic? What changes has it experienced in the lapse of geological time? What relations have these changes borne to the development of life on the land and in the water? and What is its probable future? the President astonished his audience by the array of cosmographical facts and inferences which geologists have already accumulated, and which go far to enable us to speak with some confidence on these vast operations of nature in the remote past. The bottom of the Atlantic has now been almost as carefully explored and mapped out as the two continents which bound it, and the evidence collected by the "Challenger," in deep sea, as well as by land exploration on either shore, shows the processes of change which are ever going on, and which have been doubtless going on for ages. To say nothing of volcanic disturbances on a vast scale—of which the speaker no doubt would have had more to say had he been aware of the terrestrial convulsions to which even at that moment his native continent was being subjected—boulders from the Arctic seas are being constantly carried by ice drift, and imbedded in the mud which forms the normal bottom of the Atlantic; and of living objects almost every stage of their evolution and development may be traced on both sides of the ocean separating the old and new worlds. The only thing that seems not to have changed is the oyster. The oyster is precisely what it was in the carboniferous age, a fact consoling to posterity, who may reckon on the conservative instincts of this delectable mollusc to preserve it unimpaired through the revolutionary ages in store for its human admirers.

Although the presidential address on this occasion had less to do with electrical science than any similar discourse for many years past, the subject was not without interest to the practical telegraph engineer in relation to the operations of submarine cable-laying; and we have reason to believe that some valuable contributions will be made to theoretical and applied electrical science in the course of the meeting. Ample reports of all papers likely to be of interest to readers of *The Electrician* will be supplied by our representative on the spot, and printed in these pages. Meantime we have only to congratulate the Association on the signs of continued vitality which attends its progress from year to year. Its finances appear to be in a prosperous condition, and the interest taken in its proceedings by the newspaper press shows this year no sign of abatement. One thing surprises us. Of the brilliant assembly which on Wednesday evening listened to the presidential address in the Town Hall, at Birmingham, more than half were ladies; yet the report of the Council declared that they had negatived the admission of ladies as officers of the Association, or as members of the General or Sectional Committees. We do not see how this exclusion can be maintained much longer, seeing that the Association freely admits the weaker sex to its membership—assuming, of course, that they desire to have a share in the management of its affairs. Possibly the spirit which prevails in the Council may be that of the Treasurer, who, if correctly reported, announced at the conclusion of the opening meeting, that "the total number of members enrolled was 2,222, and that among these there were

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412 ladies and a considerable number of foreigners." Ladies appear to be classed with foreigners, whose numbers need not be specified. This reminds us of a famous siege which took place a couple of centuries or so ago, and of which the historian has left record, that "thus was the city carried by fire and sword, when 5,000 souls were slain, *besides women and Jews.*"

THE THREATENED INCANDESCENT LAMP MONOPOLY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The more one thinks over the above subject the more important does the matter become, and it is one which makers of engines and dynamo machines should not lose sight of now that they have a fair chance before it is too late—that is, *if they wish to frustrate a monopoly of the lamp trade*, which should be prevented if possible, because if not, it may tend to check an important industry just now on the turning point of success.

The question is, as Mr. Shippey stated at the meeting held at the Cannon-street Hotel on the 26th ult., of national importance. On this point I quite agree with him, for what is the use of a good engine or dynamo machine without a really good and cheap lamp to produce the light at a reasonable price? The paper read by him certainly contained much interesting information. If only one-half of the facts stated by him can be proved, the outcome of this meeting may do more good than the engineering trade at present dreams of, and to my mind every support should be accorded to Messrs. Shippey's firm to assist them in carrying out their objects. If a monopoly can be frustrated, by all means let it be done. Mr. Shippey clearly stated that it was not his object to upset the Edison patents, but to keep them within the limits of the specification. I have had considerable experience in patents and patent law, and I am already of opinion that the Edison and Swan Company will not, nor can they in the face of fact adduced at the meeting, secure a monopoly of the trade if the company's patents are properly attacked.

The question of the resistance of lamps made by each maker is a point which appears to have been lost sight of. Edison claims by his specification a filament of high resistance—say 100 ohms and upwards—and has specified such a claim in his patent. He is therefore undoubtedly entitled to it, but that is all. Then, again, Shippey Brothers candidly state that their process is not suitable for incandescent lamps of high resistance, or do they, or can they, make such a lamp, their process, which is a secret one, being only suitable for glow lamps of low resistance—say from 6 to 40 or 50 ohms resistance at the outside—suitable for battery work and single domestic installations. Their specification clearly states low resistance and 50 ohms; Edison's says 100 ohms and upwards, and makes a point of this, which is one that should not be lost sight of.

Now, if the law upholds Mr. Edison's patent for a lamp of high resistance, made as described in his specification, surely the law will also protect Messrs. Shippey Brothers for their speciality of a glow lamp of low resistance. Further, even if it has been decided that Woodhouse and Rawson were making lamps which were proved to be an infringement of Edison's rights, it does not for one moment prove that the other lamp, such as the Victoria lamp, made by the Brush Corporation, or the Standard lamps sold by Messrs. Shippey's firm, or the Bernstein type, are also infringements of the Edison system, and to my mind, if the company are pinned down to the details of their specification pure and simple, such as the mode of manufacture, and materials used, and resistance claimed, that is all that can be upheld, and they have not a leg to stand upon against any patent which describes its process as entirely different, especially against such a patent as that of Shippey Brothers, who appear to have successfully made a lamp of low resistance, which Mr. Edison said was impossible. Consequently, the Edison and Swan Company will have some hard work before them, and will have many battles to fight, before they will secure a monopoly for that which they, on the face of facts, do not appear to be entitled to; and this appears to be the general opinion of those who understand the art of incandescent lamp making.—Yours, &c.,

WM. H. LE FEVRE, C.E,
Past President of the Society of Engineers.

St. Antholin's Chambers, Budge-row,
Cannon-street, E.C., Sept. 2, 1886.

THE BRITISH ASSOCIATION MEETING AT BIRMINGHAM.

(FROM OUR SPECIAL CORRESPONDENT.)

BIRMINGHAM, Thursday Evening.

The Sections opened to-day with the various Presidental addresses. The only address touching even indirectly on electrical subjects, was that of Prof. Crookes in the Chemical Section. The address of Prof. Darwin, in the Physical Section, discussed the question of a unit for geologic time. In this Section, Dr. MacAlister reported the success of the Grenada Eclipse Expedition; and among other papers read was one by Prof. Bottomley "On An Improved Mercurial Air Pump." Prof. J. Blyth also read a paper "On a New Form of Current Weigher for the Absolute Measurement of an Electric Current," and Prof. Poynting a paper "On the Proof of Cavendish's Method as to the Law of Inverse Squares." Prof. Bottomley also described experiments carried out in the Glasgow University laboratory "On the Application of Electrolysis to the Standardising of Electrical Instruments."

Prof. Poynting, in his paper, said that the proof of the law of electrical action depending on the fact that there is no electrification within a charged conductor was first given by Cavendish. His proof was made more general by Laptall, who has been followed by other writers, including Maxwell. Maxwell and MacAlister have also verified the experimental fact, repeating an investigation of Cavendish only recently published in Maxwell's edition of his researches. The proof may be analysed in the following way:—Take the case of a uniformly charged sphere. The action at a point within it may be considered as the resultant of the actions of the pairs of sections of the surfaces of all the elementary cones, with the point as vector. If, then, the resultant action is zero for all points and for all sizes of the sphere, it follows that by the action of the pair of sections each elementary cone is zero; and, since the sections of the surfaces are directly as the squares of the distances, the two sections neutralise each other. A proof was given by the author in the *Memoirs* of the Manchester Philosophical Society, 1876-7. There appears to be two objections to this proof. (1) That it takes no account of the always existing opposite charges when the sphere, for instance, is positively charged. An equal and opposite negative charge is on the walls of the room, and the action of this should be considered. Probably this objection could be removed. (2) There is a solution still simpler than the inverse square law—viz., that no element of the surface has any action within the closed conductor. If we suppose that a conductor is a complete screen to electrical action, then, whatever the law of the force exerted across an insulator, there will be no action within the conductor. In any null proof it is not sufficient merely to show that there is no action in the null arrangement, but it is also necessary to show that on disturbing the null arrangement some action is manifested. Now, in the case here considered it is impossible to obtain any action within the conductor in any statical arrangement; it is only during changes of the system while charging or discharging that we can get a disturbance of the null arrangement. But here new phenomena come in, for we have currents, and therefore electro-magnetic action. But, even disregarding the different kind of action occurring, the only experiment which I know of on this point, was that of Faraday with his electrified cube. While the most violent charges and discharges were taking place on the outside of the cube, so that the null arrangement was probably disturbed, he found no

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action on his electroscope within. Possibly the actions were alternating and so rapid that no electroscope of ordinary construction would reveal them. But he himself went into the cube, and he would probably be sensitive to rapidly alternating electromotive forces. It appears to me, then, that we cannot accept this proof, and must fall back upon the more direct proof of Coulomb. I do not know whether Maxwell was aware of this objection; but it is worthy of note that in the remarkable fragment published since his death, as "An Elementary Treatise on Electricity," he returned to Coulomb's proof, and was apparently building upon the mathematical theory of electricity in a way quite different from that followed in his larger work.

ALTERNATING AND INDUCED ELECTROMOTIVE FORCES.—V.

BY W. H. SNELL.

We have already seen that the current traversing any circuit of resistance R under an alternating E.M.F., E, of periodic time T, is numerically equal at any moment to the quotient of this E.M.F. divided by S, where S is put for

$$\left\{ R^2 + \left(\frac{2\pi L}{T}\right)^2 \right\}^{\frac{1}{2}},$$

Let us also put $\frac{2\pi}{T} = p$ for brevity, then

$$S = (R^2 + p^2 L^2)^{\frac{1}{2}}.$$

It is convenient to call S the "virtual resistance" of the circuit, or of any part of it, such as a single coil, only we have to remember that this virtual resistance is not merely a function of the constants R and L of the coil, but also of the periodic time of the alternations; so that the coil does not itself possess any one definite value of S. And further although S is always necessarily larger than R it cannot be expressed in the form $(R + a)$, but is in general a quantity incommensurable with R. If these points are borne in mind it will be found useful to employ the term "virtual resistance," and we shall not then be liable to be misled thereby.

The recent appearance of a paper by MM. Vaschy and De la Touanne "On the Numerical Values of Certain Coefficients of Self-Induction," which has been presented to the *Société Internationale des Electriciens*, and a translation of which appeared in the last number of this journal, enables me to illustrate this part of the subject by means of values taken from actual examples such as have scarcely been hitherto attainable.

From this paper we take the following values for L and R, for the cases specified:—

(A.)	Coil without core	R = 242; L = 0·233.
(B.)	Same coil with soft iron core	R = 242; L = 1·66.
(C.)	Coil with hard steel core	R = 200; L = 0·15.
(D.)	Coil with soft iron core	R = 200; L = 1·00.

The first two cases relate to the same coil, but the two latter are each distinct coils. It will be seen that the several values of L do not lie far apart; nevertheless the difference which results in the values of S, especially where T is small, are enormous. In Fig. 11, the values of S are plotted for successive values of T from 0·05 down to 0·005; that is from 20 up to 200 alternations per second.

Comparing A and B, the enormous increase in the virtual resistance of the coil when a soft iron core is introduced is at once apparent, although the second curve cannot be shown in full upon the scale of the figure. Coils C and D, again, which have each a resistance of 200 ohms for continuous currents, are seen to have a resistance of 220 ohms and 660 ohms respectively for a current with 100 alternations per second. If the periodic time be made still smaller, so as to obtain 200 alternations per second, we get a virtual resistance of 274 ohms in the first case, and 1,290 ohms in the second. The difference mainly results from the presence of soft iron in the latter coil and hard steel in the former; but as the coils are not the same, and we do not know in what way either of them is wound, we cannot tell how much of this effect is due to the winding, or how much to the the nature of the core. The bearing of these facts upon the theory of the telephone, and especially upon the resulting loss upon long lines of the higher over-tones which are essential to distinct articulation, and the curious way in which these effects may be counterbalanced by the static capacity of the line, has been thoroughly worked out by Mr. Blakesley in his papers upon Alternating Currents, although the matter still seems to be but little understood.

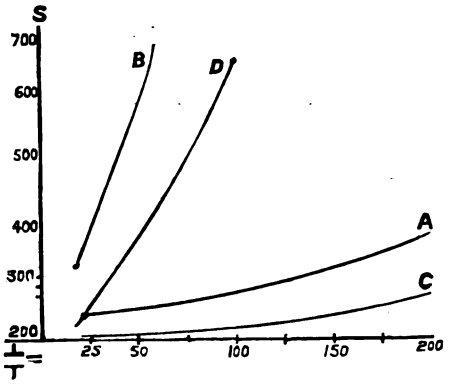

FIG. 11.

Before proceeding to the subject of mutual induction, it will be desirable to make some reference to the general problem of an alternating E.M.F. acting in a compound circuit. In the most elementary case let there be two coils connected in parallel, with resistances R_1, R_2 and self-induction coefficients L_1, L_2 respectively; let an alternating *impressed* E.M.F. act in the other part of the circuit (for which we may suppose the resistance and self-induction to be negligible). It is required to determine the current, and the angle of retardation in each part of the circuit.

Now, if at first we consider only the main branch, in which the E.M.F. is placed, it is obvious that the problem is equivalent to finding the values R_0 and L_0 for a coil such that the total current and the resultant lag shall remain unaltered when this single coil is substituted for the two in parallel. We may then say that these two sets of coils have "equivalent" resistances. It is however obvious that, just as in the case of the virtual resistance of one coil, there is no definite value of R_0 and L_0 for any two coils, except as a function of the periodic time.

The solution of this problem has been given by Lord Rayleigh in a form which is particularly convenient, because it readily permits of extension to the case of a circuit with three or more parallel branches. But for permission to make use of the following simplified method of arriving at this form of the solution the writer is indebted to the courtesy of Mr. (now Dr.) R. M. Walmsley.

In the first place, making use of equation (10) and writing p for $\frac{2\pi}{T}$, we may put down the expressions for the three currents in the circuit at any moment, thus

$$\left.\begin{aligned} I_1 &= \frac{E}{S_1}\sin(pt - \phi_1) \\ I_2 &= \frac{E}{S_2}\sin(pt - \phi_2) \\ I_0 &= \frac{E}{S_0}\sin(pt - \phi_0) \end{aligned}\right\} \quad . \quad . \quad . \qquad (15)$$

and we know also that

$$\left.\begin{aligned} \tan\phi_0 &= \frac{pL_1}{R_1} \\ \tan\phi_2 &= \frac{pL_2}{R_2} \\ \tan\phi_0 &= \frac{pL_0}{R_0} \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad . \qquad (16)$$

First, put $t = 0$, then from (15) since also

$$I_0 = I_1 + I_2 \quad \text{(always)} \quad . \quad . \quad . \quad . \qquad (17)$$

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we have $$\frac{\sin\phi_0}{S_0}=\frac{\sin\phi_1}{S_1}+\frac{\sin\phi_2}{S_2}.$$

But from equation (16)

$$\sin\phi_1=\frac{pL_1}{S_1}$$

$$\sin\phi_2=\frac{pL_2}{S_2}$$

$$\sin\phi_0=\frac{pL_0}{S_0}$$

$$\therefore\quad \frac{L_0}{S_0^2}=\frac{L_1}{S_1^2}+\frac{L_2}{S_2^2}=Q \text{ suppose} \quad . \quad . \quad (18)$$

Next, put $p\,t=\frac{\pi}{2}$. Then from (15) and (17)

$$\frac{\cos\phi_0}{S_0}=\frac{\cos\phi_1}{S_1}+\frac{\cos\phi_2}{S_2},$$

which gives, with the values of sin ϕ_0, &c., just obtained,

$$\frac{R_0}{S_0^2}=\frac{R_1}{S_1^2}+\frac{R_2}{S_2^2}=P \text{ (suppose)} \quad . \quad (19)$$

Re-writing (18) and (19)

$$Q=\frac{L_0}{R_0^2+p^2L_0^2}$$

$$P=\frac{R_0}{R_0^2+p^2L_0^2}$$

whence $$R_0^2+p^2L_0^2=\frac{1}{P^2+p^2Q^2}$$

and $$R_0=\frac{P}{P^2+p^2Q^2} \quad . \quad . \quad . \quad . \quad . \quad (20)$$

$$L_0=\frac{Q}{P^2+p^2Q^2} \quad . \quad . \quad . \quad . \quad . \quad (21)$$

But from (18) and (19) the values of P and Q are given in terms of R_1 L_1 and R_2 L_2, hence R_0 and L_0 are found in known terms. The extension to three or more branches is obtained by simply adding the successive terms to P and Q in (18) and (19), and using these values in (20) and (21).

The fact that the angle of retardation is not necessarily the same in the two branches shows that there may be a circular current around this part of the circuit alone. It is unfortunately difficult to show exactly how R_0 and L_0 vary with the constants of the two coils; if the above expressions are written out in full they become very unwieldy. The correctness of the formula may readily be inferred by making L_1 and L_2 vanish in the expression for R_0, when it will be found to result in the ordinary formula for the resistance of compound circuits.

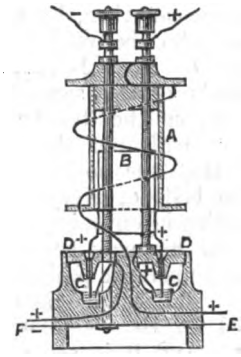
A NEW AUTOMATIC SWITCH.

In ordinary incandescent lighting it is often desirable, and on the multiple series system it is even necessary, to provide means by which a fresh lamp is substituted upon the breaking of a filament in one of those burning. A novel automatic switch designed for this purpose is that shown in section in the accompanying illustration. It is the design of M. L. Clerc. It consists of a vertical solenoid A included in the circuit of the active lamp. Within the solenoid there plays a core or tubular plunger B of thin sheet-iron, which carries two rods C at its lower end, arranged so as to dip into two mercury troughs D. When the active lamp (connected at E) burns, the current passing in the solenoid raises the cylinder, and the circuit of the reserve lamp is open. Should an accident occur to the first lamp, the cylinder drops, the rods plunge into the troughs of mercury, and the circuit of the reserve lamp connected at F is closed. The light is therefore interrupted only for an instant.

When the lamp is switched off in the regular way, the stoppage of the current allows the cylinder to fall. Thus, when the lamp in service is switched on again, the current for an instant passes through both lamps; but as the cylinder is almost instantly raised, the reserve lamp is cut out.

The mercury troughs are arranged so as to prevent spilling of the mercury, and have small conical openings at the top, to allow it to be conveniently poured in.

Since it requires power to keep the solenoid A energised, M. Clerc has sought to reduce that as much as possible by favourable construction, so that the electrical energy consumed in the solenoid does not exceed one watt.



New Automatic Switch.

If it is desired to have both lamps lit at the same time, this can be arranged by inserting an interrupter, which suppresses temporarily the function of the apparatus, and thus leaves both lamps in circuit.—*Electrical World.*

AN "AUTOMATIC DISTRIBUTOR" FOR TELEPHONE CIRCUITS.

The "automatic distributor" is the outcome of the combined labours of MM. Ericsson, Cedergren, Nyström, and Wennmann, the two latter being connected with the Swedish Telegraph Administration. By the employment of this apparatus it is possible to serve five different subscribers upon the same wire; if necessary, this number might easily be increased. We take the following description from the *Journal Télégraphique.* The automatic distributor, which is represented in Fig. 1, is intended for use upon telephone lines which are provided with magneto call signals. The apparatus, however, requires the use of a continuous current in addition to the magneto. Fig. 2 shows the connection of the various parts of the distributor with which each subscriber is provided. G is a polarised switch, which may be made to close the circuit of either of the magnets M or M_1, according to the direction of the battery current. A is the distributor proper, consisting of a needle moving over a dial. B, C, D, E, F is an "interruptor." The principal office of the latter instrument is (as its name does *not* very clearly imply) to enable any subscriber to connect his line with the exchange. The distributor A is actuated on the part of the exchange by means of a succession of positive currents, the number corresponding to the number of the subscriber. When the signal to switch off is given, the distributor is replaced in its normal position by means of *one* negative current.

Having given this general idea of the nature of the apparatus, we shall now proceed to follow its action in detail, and to trace the path of the currents by means of Fig. 2.

1st. The apparatus being at rest in the position indicated by the figure, the exchange wishes to establish communication with subscriber No. 1.—The exchange first sends one positive current to the line. The current passes first through the polarised relay, thence through the upper stops of the armatures of M and M_1, and divides among the five contact springs a_1.....a_5, and through the five electromagnets E, the springs D, and the contacts *e* of the "interruptors." It has already been mentioned that only one of these five interruptors is shown in the figure. A moment later the polarised armature (*m*) of the magnet G closes the contact *a*, and puts the coil M to earth. Consequently the current now divides at the point *f*, one part passes through the electromagnet M, and thence through the tongue *m* to earth. The armature of M being thus attracted interrupts the circuit first described by which the current passes to

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the five lines L_1.....L_5. Now the armature of M is in mechanical connection with a pallet, not indicated in the figure, which acts upon an escapement wheel fixed upon the same axis as the needle *v*. Thus the positive current sent from the exchange causes the needle to advance one step, where it makes contact with a pin joined directly to the line L_1. By the same movement of the needle in question, the connection of the springs a_1.....a_5 with the needle *v* has been interrupted. The exchange can then, by means of its magneto-inductor, call up the subscriber on line L_1 without interfering with the subscribers on lines L_2 ..... L_5; and by reason of the rapid reversals of the signalling current no effect will be produced upon the tongue of the relay G, and the needle *v* will not be again disturbed. It must be admitted that the positive current first sent to line may sound the bells of every one of the subscribers; but this is a very trifling inconvenience, as only a single stroke can be given, and even this may be avoided by causing the hammer to rest always upon the positive side.

It is unnecessary to add that the same intermediate contacts which are established for the signalling circuit serve also for the speaking circuit. And it is also evident that the conversation cannot be overheard by those subscribers who have not been called. The employment of the distributors does not introduce any deviation from the main circuit, and the only additional resistance is that of the relay G, which is about 30 ohms.

When the conversation has ended the exchange sends one negative current upon the line, which follows at first the same path as the telephonic currents. But the next instant the tongue *m* closes the lower contact *b*, and the current again divides at the point *f*. A part of the current now traverses the coils of the electro-magnet M, and the movement of the armature releases the pallet of the escapement wheel, and also the needle *v*. The latter is then brought back to its original position by means of a spiral spring, to which it is attached.

2nd. The apparatus being at rest, subscriber No. 1 calls the exchange.—The magneto current passes through the distributor by the following path :—Lever B, contact point *e*, spring D, electro-magnet E, spring *a*. From this point the current is momentarily divided amongst the other four lines; but this circuit is immediately interrupted. In fact, all the electro-magnets of the interruptors E_1.....E_5 are provided with polarised armatures. Consequently, the armature E, which alone receives the full current, is at once pulled over, and so interrupts the circuit of the lines L_2.....L_5. The upper end F of the pin projecting from this armature turns to the left, and the left-hand extremity of the lever B, which rested upon this pin, falls, and so makes contact at *c* between B and F. The right-hand extremity of the same lever B then presses against and lifts the insulated end of the screw *s*, and turns the elbow lever C so that the screw *h*, which is also insulated at its extremity, *d*, is moved to the left, and presses back the spring D. The five bent levers C_1.....C_5 are all placed upon a common axis. Consequently, when any one of these levers opens its spring contact D, all the similar contacts are opened, and these circuits are simultaneously interrupted. The circuit of the magnets is now maintained through the point of contact *c*, between F and B, thence through the needle *v*, directly to the exchange. The only additional resistance is that of the relay G. The telephone current follows the same route.

The conversation being ended, the central station again sends a negative current, bringing the electro-magnet M_1 into action. This current does not produce any effect at this time upon needle *v*, which is already at zero. But the armature of M_1 is also in mechanical connection with the extremity *s* of the bent lever C, which, in consequence, follows the movement of the armature as it falls. The lever B of the line L, which had been disconnected, is then replaced in its normal position, resting upon the top of the pin of the armature F, from which it is, however, insulated by a piece of ebonite as already intimated. The whole apparatus has now returned to its normal condition.

3rd. The apparatus being at rest, subscriber No. 1 wishes to speak to No. 5.—The subscriber first calls the exchange in the manner already described, and asks to be connected with L_5. The exchange then sends nine positive currents to line, the first contact being held down rather longer than the others in order to give the polarised switch time to fall over. The needle *v* is thus led to the contact-piece marked "1—5" upon the dial. In this position the needle makes contact at one end with L_5, and upon an inner circle the other end makes contact with L_1 upon the disc *n*. The line L to the exchange is at the same time maintained in contact with the needle *v*. It follows that the telephone currents which pass between L_1 and L_5 are tapped through the exchange, which is thus able to discover whether the two

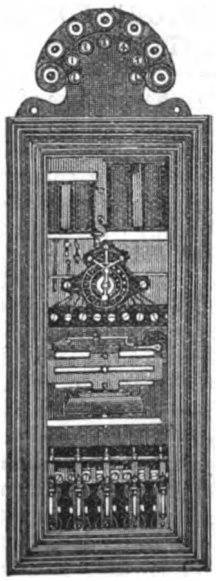

FIG. 1.

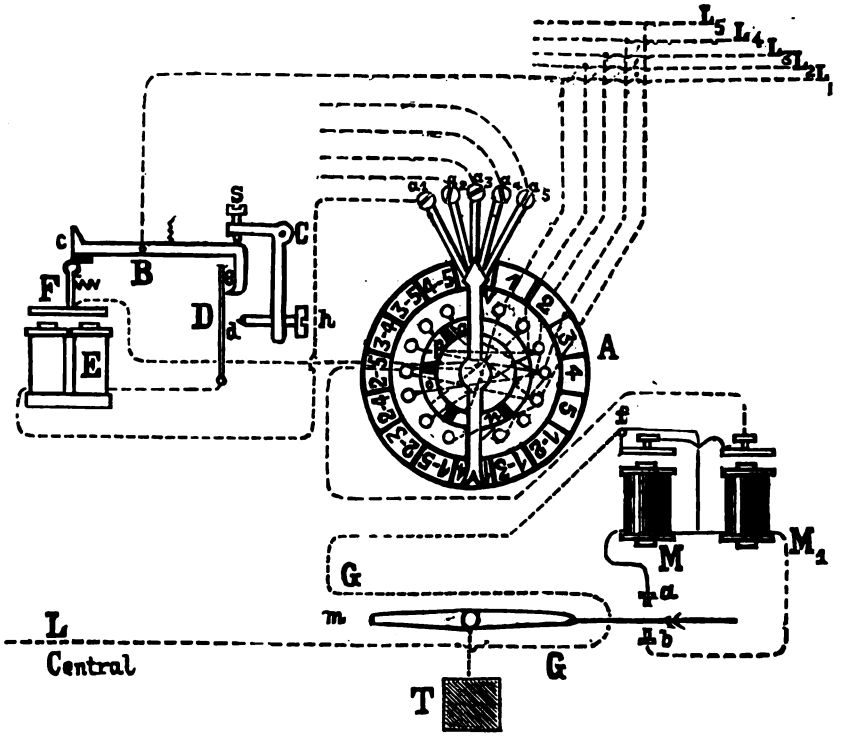

FIG. 2.

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subscribers are in communication, and also to know when they have finished their conversation. In order that this shunt circuit may not interfere with the distinctness of the conversation between L_1 and L_5, an additional resistance is at the same time inserted in the line between L and earth.

The dial of the distributor in the same way possesses a separate contact piece for every distinct pair of lines. Thus, for five subscribers we require altogether 16 sections, including one for the zero position. The apparatus has been found to act well, and does not easily get out of order. If an error should be made in the signals, the needle can immediately be restored to the zero position. It has generally been found that the introduction of this apparatus permits a reduction to be made in the tariff for the exchange service.

ON THE MAGNETIC TORSION OF IRON AND NICKEL WIRES.

BY SHELFORD BIDWELL, M.A., F.R.S.*

In a paper published in the *Phil. Mag.* for July, 1886, p. 50, Prof. G. Wiedemann refers to his well-known experimental researches into relations between the torsion and magnetisation of iron wires. Let a longitudinally magnetised wire, NS, befixed at the south end of S, the other end N being free, and let a battery current be passed through it from S to N, then the free end will be observed to twist in the direction of the hands of a clock as seen from the fixed end.

Maxwell† explains the phenomenon thus. The wire being magnetised both circularly and longitudinally, the resultant magnetisation is in the direction of a right-handed screw round the wire. Now Joule found that an iron bar when longitudinally magnetised was increased in length, its tranverse dimensions being at the same time contracted. We should expect, therefore, that a spirally magnetised wire would expand in the direction of the magnetisation and contract in directions at right angles to the magnetisation. And thus the twisting would be produced.

This explanation assumes that the torsional effect is simply secondary to and dependent upon the phenomena observed by Joule, and Prof. Wiedemann, for reasons given in his paper, appears not to be satisfied with it.

Some additional light may perhaps be thrown on the subject by a few experiments which I made at the beginning of the present year. They were intended to be merely of a preliminary nature, and I had hoped to be able to carry them further; but so far as they go they appear to be conclusive, and a short account of them may be of interest at the present time in connection with the recent publication of Prof. Wiedemann.

In two papers communicated to the Royal Society,‡ I have pointed out that the effect of magnetisation upon the dimensions of an iron rod is not so simple as it had previously been believed to be. Joule enunciated the law that the elongation in a given bar is at first proportional to the magnetic intensity, and that it ceases to increase after the iron is fully "saturated." My own experiments show that if the magnetisation is carried beyond the point at which the elongation reaches a maximum, the length of the rod, instead of remaining unchanged, steadily diminishes, until, when the magnetising current has attained a certain strength, the original length of the rod is unaffected, and if this strength be exceeded actual *retraction* is produced. From some further experiments, details of which are not yet published, it appears that effects of the same character occur when rings are used instead of straight rods. The diameter of an iron ring surrounded by a coil of wire was found to be increased when a comparatively small current was passed through the coil and diminished when the current was strong.

I have also carried further Joule's experiments regarding the effects of magnetisation upon the length of iron wires under tension, and ascertained, among other things, that a wire when stretched by a weight attains its maximum elongation with a smaller external magnetising force than when it is free, retraction apparently beginning at an earlier stage of magnetisation.

Lastly, I have repeated and confirmed the experiments of Barrett* upon nickel. Barrett discovered that the length of a nickel bar when longitudinally magnetised was diminished. So far as appears from his published papers on the subject, which are very brief, he worked only with comparatively strong magnetising currents, and it seemed to me possible that, as in the case of iron, weaker currents might cause elongation. But on trying the experiment I found that this was not so. Magnetising forces which were so small as to produce no sensible effect whatever upon iron caused considerable diminution in the length of the nickel bar, and the curve of retraction given in my paper clearly passes through the intersection of the axes, and shows quite conclusively that elongation cannot occur at any early stage of the magnetisation.

Here, then, we have three classes of phenomena, which, if Maxwell's explanation were correct, would enable us to predict certain variations in the torsional effects observed by Wiedemann.

Let us consider the first case of nickel. According to Maxwell, a spirally magnetised iron wire is twisted in a certain manner, because the iron expands in the direction of the magnetisation. Since, then, nickel contracts in the direction of the magnetisation, we should expect a nickel wire to twist oppositely to an iron wire under similar conditions. This I found to be so. Whether the magnetising currents were strong or weak, the twist of the nickel wire was always in the direction opposite to that given by Wiedemann for iron.

I was not aware until I read Wiedemann's recent paper that this experiment had been performed previously.† Wiedemann discusses it fully and admits that the facts accord with Maxwell's explanation. But he appears to consider that it is a case of merely accidental coincidence: it is true that when longitudinally magnetised, iron expands while nickel contracts, and it is true that, when spirally magnetised, iron and nickel twist oppositely; but the two sets of phenomena are quite independent and are not related to one another as cause and effect. The torsion is to be explained, he thinks, by supposing that "the obliquely spiral direction which the molecules take up in consequence of the two magnetisations at right angles to each other" is, owing to intermolecular friction, "accompanied by a displacement of the longitudinal fibres and [of the] sections of the wires." In iron the friction of the longitudinal fibres is the greatest, and thus the torsion in the observed direction is accounted for. In nickel the friction of the sections predominates; a nickel wire is therefore twisted oppositely to an iron wire. For a more complete statement of Wiedemann's views reference must be made to the paper.‡

The behaviour of nickel, then, though in agreement with Maxwell's hypothesis, is not accepted by Wiedemann as affording confirmation of it.

But we have further means of testing the hypothesis. It has been said that an iron rod when very strongly magnetised is contracted instead of being elongated. Moreover, when the rod is stretched by a weight contraction occurs with smaller magnetising forces than when it is unstretched. In accordance with Maxwell's explanation, therefore, an iron wire spirally magnetised by very strong currents should twist (just as if it were a nickel wire) in the opposite direction to that indicated by Wiedemann for iron; and this reversal of the

* From the *Phil. Mag.* for September. † "Electricity" II., §448.
‡ *Proceedings*, Royal Society, XL., pp. 109,257.

* *Nature*, XXVI. 585, and British Association Report, 1882.
† Knott, *Proc.* Roy. Soc. Edin. 1882-3. Quoted by Wiedemann.
‡ I confess that I do not find it easy to follow the suggested explanation. Passing over preliminary difficulties, and assuming that the friction between the polar ends of adjoining molecules is different from that between their sides, it seems to me that the observed torsions could only be accounted for by assuming that in iron the friction of the ends is greater than the lateral friction, while in nickel the lateral friction is greatest. This appears to be directly opposed to Wiedemann's statement; but though I have considered the question carefully, and from several points of view, I can arrive at no other conclusion. It is, however, possible that I may have altogether misunderstood the argument, the more so as the paper referred to is a translation.

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twist should take place at an earlier stage of the magnetisation if the wire were stretched. Now this is exactly what I have found to be the case. The free end of an iron wire, through which a constant current is passing, can be made to twist in either direction by varying the current through the surrounding helix, while with a certain medium strength of current there is no movement at all. And again, when the wire is loaded with a weight, the current which produces no torsion is considerably diminished, the reversal of the torsion also, of course, occurring with smaller currents.

It is not easy to see how Wiedemann's theory could fairly be made to explain these phenomena. He would be compelled to assume that when the iron is more intensely magnetised, that is, when the molecules are more completely turned in the same direction, the excess of longitudinal over transverse molecular friction, instead of becoming more marked, as might naturally be expected, would be decreased, and, with a sufficient degree of magnetisation, even converted into a deficiency. It would also be necessary to assume that when the molecules of a wire are drawn apart by stretching, the friction between their ends is nevertheless greater. Such assumptions would, I think, be highly unscientific.

On the other hand, Maxwell's explanation, which does not seek to go behind the magnetic elongations and retractions detected by Joule and others, fits the newly observed facts easily and naturally.

Note on the Experiments.—It seems desirable to give a few details of the experiments above referred to, though too much importance must not be attached to the quantitative results :—

The iron wire used was ·7mm. in diameter and 20cm. long. It was suspended in an upright position from a fixed clamp, and passed through a helix consisting of 876 turns of copper wire in 12 layers. To the lower end of the supended wire was fixed a small plane mirror which reflected an indicating beam of light upon an ordinary galvanometer scale 127cm. distant from it. Each scale division was equal to ·64mm. A steady current of about 1 ampere was passed through the iron wire from the clamp to the free end, which dipped into a mercury cup. The magnetising coil was in circuit with a battery of 7 Grove cells, a box of resistance coils, a tangent galvanometer, and a contact key.

The deflections of the spot of light when various currents were passed through the coil are given below :—

Iron wire unstretched.

Current.	Deflection.
0·36 ampere.	+ 7 divisions.
1·2 „	0 „
3·7 „	− 4 „

Same wire loaded with 6·3 kilos.

0·33 ampere.	+ 2 divisions.
0·59 „	0 „
3·68 „	− 3 „

The current which produced no deflection was obtained tentatively by varying the resistance ; a current slightly stronger or weaker than that indicated caused a perceptible deflection in one direction or the other It will be seen that when the wire was loaded with a weight of 6·3 kilogrammes the current causing no deflection was reduced to one half of its former value. The deflections given above are those produced by the second and subsequent currents of the strength denoted. That due to the first current was uncertain, depending probably upon the previously existing permanent magnetism of the wire. This point, amongst others, requires further investigation.

PHOTOMETRY.

Herr Strecker has given a review of the whole question of photometric measurements, and of the various kinds of photometers invented at various times. Since the lights which we have to measure are only perceived by the eye, it is to the eye that we must appeal for the final test of the equality of lights ; and it is not desirable to make use of some other effect of light than that produced on the retina, such, for instance, as the action of light on selenium or on some chemical compounds. The eye being the ultimate test, it remains to be seen which is the best instrument to assist the eye in its decision, and this appears undoubtedly to be the form of photometer due to Bunsen, in which a screen of paper with a grease spot in the centre serves to show when the illuminating powers of two sources of light have equal effect on it. In some cases it is preferable to use, in place of the single sheet of paper with the grease spot, three thicknesses of paper, the middle one having a geometric figure of some kind, generally a star, cut out of it With regard to the standard with which the light is to be compared, the standard candle cannot be recommended, except in the hands of very skilled and competent observers. The normal unit lamp proposed by v. Hefner-Alteneck, in which amyl acetate is burned, can be depended upon with far greater certainty to produce always the same light for the same height of flame ; the standard candles, on the average, being about 3 per cent. out. It is desirable, however, when measuring lights of great intensity, to have an intermediate standard, which is first compared with the standard unit, and then in turn used for comparison with the experimental light. For such a purpose a petroleum lamp of good construction, or a gas flame burning under constant pressure, may be used. A ready method of comparing a batch of glow lamps is the following :—In the circuit of a battery are introduced two branch circuits in parallel : the one contains a standard glow lamp of the same type as those to be tested, a resistance, and one coil of a differential galvanometer ; the other branch circuit contains the lamp to be tested, a resistance, and the second coil of the differential galvanometer. From one terminal of the standard lamp to one terminal of the experimental lamp is a circuit of very high known resistance containing a galvanometer ; this latter serves to show the difference of potential between the two lamps, while the differential galvanometer shows the difference in current, and the photometer the difference in light, and the whole of the measurements can conveniently be taken at once.—*Journal of Telegraph-Engineers.*

THE BRITISH ASSOCIATION MEETING.

The following is the Presidential address of Sir William Dawson. C.M.G., M.A., LL.D., F.R.S., F.G.S., Principal and Vice-Chancellor of M'Gill University, Montreal, Canada :—

Twenty-one years have passed away since the last meeting of the British Association in this great central city of England. At the third Birmingham meeting—that of 1865—I had the pleasure of being present, and had the honour of being one of the Vice-Presidents of Section C. At that meeting my friend John Phillips, one of the founders of the Association, occupied the Presidential chair, and I cannot better introduce what I have to say this evening than by the eloquent words in which he then addressed you :—"Assembled for the third time in this busy centre of industrious England, amid the roar of engines and clang of hammers, where the strongest powers of nature are trained to work in the fairy chains of art, how softly and fittingly falls upon the ear the accent of science, the friend of that art, and the guide of that industry ! Here where Priestley analysed the air, and Watt obtained the mastery over steam, it well becomes the students of nature to gather round the standard which they carried so far into the fields of knowledge. And when on other occasions we meet in quiet colleges and academic halls, how gladly welcome is the union of fresh discoveries and new inventions with the solid and venerable truths which are there treasured and taught. Long may such union last ; the fair alliance of cultivated thought and practical skill ; for by it labour is dignified and science fertilised, and the condition of human society exalted." These were the words of a man who, while earnest in the pursuit of science, was full of broad and kindly sympathy for his fellow men, and of hopeful confidence in the future. We have but to turn to the twenty reports of this Association, issued since 1865, to see the realisation of that union of science and art to which he so confidently looked forward, and to appreciate the stupendous results which it has achieved. In one department alone—that to which my predecessor in this chair so eloquently adverted in Aberdeen, the department of education in science—how much has been accomplished since 1865. Phillips himself lived to see a great revolution in this respect at Oxford. But no one in 1865 could have anticipated that immense development of local schools of science of which your own Mason College and your admirable technical, industrial, and art schools are eminent examples. Based on the general education given by the new system of Board schools, with which the name of the late W. E. Forster will ever be honourably connected, and extending its influence upward to special training and to the highest university examinations, this new scientific culture is opening paths of honourable ambition to the men and women of England scarcely dreamed of in 1865. I sympathise with the earnest appeal of Sir Lyon Playfair, in his Aberdeen address, in favour of scientific education ; but visiting England at rare intervals, I am more impressed with the progress that has been made than with the vexatious delays which have occurred.

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No one could have anticipated twenty years ago that a Birmingham manufacturer, in whose youthful days there were no schools of science for the people, was about to endow a college, not only worthy of this great city, but one of its brightest ornaments.* Nor could anyone have foreseen the great development of local scientific societies, like your Midland Institute and Philosophical Society, which are now flourishing in every large town and in many of those of less magnitude. The period of twenty-one years that has elapsed since the last Birmingham meeting has also been an era of public museums and laboratories for the teaching of science, from the magnificent national institutions at South Kensington and those of the great universities and their colleges down to those of the schools and field clubs in country towns. It has besides been an era of gigantic progress in original work and in publication—a progress so rapid that workers in every branch of study have been reluctantly obliged to narrow in more and more their range of reading and of effort to keep abreast of the advance in their several departments. Lastly, these twenty-one years have been characterised as the "coming of age" of that great system of philosophy with which the names of three Englishmen—Darwin, Spencer, and Wallace—are associated as its founders Whatever opinions one may entertain as to the sufficiency and finality of this philosophy there can be no question as to its influence on scientific thought. On the one hand it is inaccurate to compare it with so entirely different things as the discovery of the chemical elements and of the law of gravitation; on the other, it is scarcely fair to characterise it as a mere "confused development" of the mind of the age. It is indeed a new attempt of science in its maturer years to grapple with those mysterious questions of origins which occupied it in the days of its infancy, and it is to be hoped that it may not, like the Titans of the ancient fable, be hurled back from heaven, or like the first mother find the knowledge to which it aspires a bitter thing. In any case we should fully understand the responsibility which we incur when in these times of full-grown science we venture to deal with the great problem of origins, and should be prepared to find that in this field the new philosophy, like those which have preceded it, may meet with very imperfect success. The agitation of these subjects has already brought science into close relations, sometimes friendly, sometimes hostile, it is to be hoped in the end helpful, with those great and awful questions of the ultimate destiny of humanity, and its relations to its Creator, which must always be nearer to the human heart than any of the achievements of science on its own ground. In entering on such questions we should proceed with caution and reverence, feeling that we are on holy ground, and that though, like Moses of old, we may be armed with all the learning of our time, we are in the presence of that which while it burns is not consumed; of a mystery which neither observation, experiment, nor induction can ever fully solve.

In a recent address, the late President of the Royal Society called attention to the fact that within the lifetime of the older men of science of the present day the greater part of the vast body of knowledge included in the modern sciences of physics, chemistry, biology, and geology has been accumulated, and the most important advances made in its application to such common and familar things as the railway, ocean navigation, the electric telegraph, electric lighting, the telephone, the germ theory of disease, the use of anæsthetics, the processes of metallurgy, and the dyeing of fabrics. Even since the last meeting in this city, much of this great work has been done, and has led to general results of the most marvellous kind. What at that time could have appeared more chimerical than the opening up by the enterprise of one British colony of a shorter road to the East by way of the extreme west, realising what was happily called by Milton and Cheadle "the new North-west Passage," making Japan the next neighbour of Canada on the west, and offering to Britain a new way to her Eastern possessions; or than the possibility of this Association holding a successful meeting on the other side of the Atlantic? To have ventured to predict such things in 1865, would have appeared quite visionary, yet we are now invited to meet in Australia, and may proceed thither by the Canadian Pacific Railway, and its new lines of steamers, returning by the Suez Canal.† To-day this is quite as feasible as the Canadian visit would have been in 1885. It is science that has thus brought the once widely separated parts of the world nearer to each other, and is breaking down those geographical barriers which have separated the different portions of our widely extended British race. Its work in this is not yet complete. Its goal to-day is its starting point to-morrow. It is as far as at any previous time from seeing the limit of its conquests, and every victory gained is but the opening of the way for a further advance.

By its visit to Canada the British Association has asserted its imperial character, and has consolidated the scientific interests of Her Majesty's dominions, in advance of that great gathering of the industrial products of all parts of the empire now on exhibition in London, and in advance of any political plans of Imperial federation.‡ There has even been a project before us for an international scientific convention, in which the great English republic of America shall take part, a project, the realisation of which was to some extent anticipated in the fusion of the members of the British and American Associations at Montreal and Philadelphia in 1884. As a Canadian, as a past President of the American Association, and now honoured with the Presidency of this Association, I may be held to represent in my own person this scientific union of the British Islands, of the various Colonies, and of the great Republic, which, whatever the difficulties attending its formal accomplishment at present, is certain to lead to an actual and real union for scientific work. In furtherance of this I am glad to see here to-day influential representatives of most of the British Colonies, of India, and of the United States. We welcome here also delegates from other countries, and though the barrier of language may at present prevent a larger union, we may entertain the hope that Britain, America, India, and the Colonies, working together in the interests of science, may ultimately render our English tongue the most general vehicle of scientific thought and discovery, a consummation of which, I think, there are, at present, many indications.

But, while science marches on from victory to victory, its path is marked by the resting-places of those who have fought its battles and assured its advance. In looking back to 1865 there rise before me the once familiar countenances of Phillips, Murchison, Lyell, Forbes, Jeffreys, Jukes, Rolleston, Millar, Spottiswoode, Fairbairn, Gassiot, Carpenter, and a host of others, present in full vigour at that meeting, but no more with us. These were veterans of science; but, alas! many then young and rising in fame are also numbered with the dead. It may be that before another Birmingham meeting many of us, the older members now, will also have passed away. But these men have left behind them ineffaceable monuments of their work, in which they still survive, and we rejoice to believe that, though dead to us, they live in that company of the great and good of all ages who have entered into that unseen universe where all that is high and holy and beautiful must go on accumulating till the time of the restitution of all things. Let us follow their example and carry on their work, as God may give us power and opportunity, gathering in precious stores of knowledge and of thought, in the belief that all truth is immortal, and must go on for ever bestowing blessings on mankind. Thus will the memory of the mighty dead remain to us as a power which—

Like a star
Beacons from the abode where the eternal are.

I do not wish, however, to occupy your time longer with general or personal matters, but rather to take the opportunity afforded by this address to invite your attention to some topics of scientific interest. In attempting to do this I must have before me the warning conveyed by Professor Huxley, in the address to which I have already referred, that in our time science, like Tarpeia, may be crushed with the weight of the rewards bestowed on her. In other words, it is impossible for any man to keep pace with the progress of more than one limited branch of science, and it is equally impossible to find an audience of scientific men of whom anything more than a mere fraction can be expected to take an interest in any one subject. There is, however, some consolation in the knowledge that a speaker who is sufficiently simple for those who are advanced specialists in other departments will of necessity be also sufficiently simple to be understood by the general public who are specialists in nothing. On this principle a geologist of the old school, accustomed to a great variety of work, may hope so to scatter his fire as to reach the greater part of his audience. In endeavouring to secure this end, I have sought inspiration from that ocean which connects rather than separates Britain and America, and may almost be said to be an English sea—the North Atlantic. The geological history of this depression of the earth's crust, and its relation to the continental masses which limit it, may furnish a theme at once generally intelligible and connected with great questions as to the structure and history of the earth, which have excited the attention alike of physicists, geologists, biologists, geographers, and ethnologists. Should I, in treating of these questions, appear to be somewhat abrupt and dogmatic, and to indicate rather than state the evidence of the general views announced, I trust you will kindly attribute this to the exigencies of a short address.

If we imagine an observer contemplating the earth from a convenient distance in space, and scrutinising its features as it rolls before him, we may suppose him to be struck with the fact that eleven-sixteenths of its surface are covered with water, and that the land is so unequally distributed that from one point of view he would see a hemisphere almost exclusively oceanic, while nearly the whole of the dry land is gathered in the opposite hemisphere. He might observe that the great oceanic area of the Pacific and Antarctic Oceans is dotted with islands—like a shallow pool with stones rising above its surface—as if its general depth were small in comparison with its area. He might also notice that a mass or belt of land surrounds each pole, and that the northern ring sends off to the southward three vast tongues of land and of mountain chains, terminating respectively in South America, South Africa, and Australia, towards which feebler and insular processes are given off by the Antarctic continental mass. This, as some geographers have observed,* gives a rudely three-ribbed aspect to the earth, though two of the three ribs are crowded together and form the Europ-asian mass or double continent, while the third is isolated in the single continent of America. He might also observe that the northern girdle is cut across, so that the Atlantic opens by a wide space into the Arctic sea, while the Pacific is contracted toward the north, but confluent with the Antarctic Ocean. The Atlantic is also relatively deeper and less cumbered with islands than the Pacific, which has the higher ridges near its shores, constituting what some visitors to the Pacific coast of America have not inaptly called the "back of the world," while the wider slopes face the narrower ocean, into which for this reason the greater part of the drainage of the land is poured.† The Pacific and Atlantic, though both depressions or flattenings of the earth, are, as we shall find, different in age, character, and conditions; and the Atlantic, though the smaller, is the older, and

* It was in 1865 that Sir Josiah Mason was, quietly and without any public note, beginning to lay the foundation of his orphanage at Erdington.

† It is expected that on the completion of the connections of the Canadian Pacific Railway the time from ocean to ocean may be reduced to 116 hours, and from London to Hong Kong to twenty-seven days.

‡ I should note here, in connection with this, the valuable volume of *Canadian Economics*, edited by Mr. D. A. P. Watt, which was one of the results of the Montreal meeting.

* Dana, "Manual of Geology," introductory part. Green, "Vestages of a Molten Globe," has summed up these facts.

† Mr. Millard Reade, in two Presidential addresses before the Geological Society of Liverpool, has well illustrated this point and its geological consequences.

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from the geological point of view, in some respects, the more important of the two.

If our imaginary observer had the means of knowing anything of the rock formations of the continents, he would notice that those bounding the North Atlantic are in general of great age, some belonging to the Laurentian system. On the other hand, he would see that many of the mountain ranges along the Pacific are comparatively new, and that modern igneous action occurs in connection with them. Thus he might be led to believe that the Atlantic, though comparatively narrow, is an older feature of the earth's surface, while the Pacific belongs to more modern times. But he would note in connection with this that the oldest rocks of the great continental masses are mostly toward their northern ends, and that the borders of the northern ring of land and certain ridges extending southwards from it constitute the most ancient and permanent elevations of the earth's crust, though now greatly surpassed by mountains of more recent age nearer the equator. Before leaving this general survey we may make one further remark. An observer looking at the earth from without would notice that the margins of the Atlantic and the main lines of direction of its mountain chains are north-east and south-west, and north-west and south-east, as if some early causes had determined the occurrence of elevations along great circles of the earth's surface tangent to the polar circles.

We are invited by the preceding general glance at the surface of the earth to ask certain questions respecting the Atlantic. (1) What has at first determined its position and form? (2) What changes has it experienced in the lapse of geological time? (3) What relations have these changes borne to the development of life on the land and in the water? (4) What is its probable future?

Before attempting to answer these questions, which I shall not take up formally in succession, but, rather in connection with each other, it is necessary to state as briefly as possible certain general conclusions respecting the interior of the earth. It is popularly supposed that we know nothing of this beyond a superficial crust perhaps averaging 50,000 to 100,000 feet in thickness. It is true we have no means of exploration in the earth's interior, but the conjoined labours of physicists and geologists have now proceeded sufficiently far to throw much inferential light on the subject, and to enable us to make some general affirmations with certainty; and these it is the more necessary to state distinctly, since they are often treated as mere subjects of speculation and fruitless discussion.

(1) Since the dawn of geological science, it has been evident that the crust on which we live must be supported on a plastic or partially liquid mass of heated rock, approximately uniform in quality under the whole of its area. This is a legitimate conclusion from the wide distribution of volcanic phenomena, and from the fact that the ejections of volcanoes, while locally of various kinds, are similar in every part of the world. It led to the old idea of a fluid interior of the earth, but this is now generally abandoned, and this interior heated and plastic layer is regarded as merely an under-crust.

(2) We have reason to believe, as the result of astronomical investigations,* that, notwithstanding the plasticity or liquidity of the under-crust, the mass of the earth—its nucleus as we may call it—is practically solid and of great density and hardness. Thus we have the apparent paradox of a solid yet fluid earth; solid in its astronomical relations, liquid or plastic for the purposes of volcanic action and superficial movements.†

(3) The plastic sub-crust is not in a state of dry igneous fusion, but in that condition of aqueo-igneous or hydro-thermic fusion which arises from the action of heat on moist substances, and which may either be regarded as a fusion or as a species of solution at a very high temperature. This we learn from the phenomena of volcanic action, and from the composition of the volcanic and plutonic rocks, as well as from such chemical experiments as those of Daubré and of Tilden and Shenstone.‡

(4) The interior sub-crust is not perfectly homogeneous, but may be roughly divided into two layers or magmas, as they have been called; an upper, highly siliceous or acidic, of low specific gravity and light-coloured, and corresponding to such kinds of plutonic and volcanic rocks as granite and trachyte; and a lower, less siliceous, or more basic, more dense, and more highly charged with iron, and corresponding to such igneous rocks as the dolerites, basalts, and kindred lavas. It is interesting here to note that this conclusion, elaborated by Durocher and von Waltershausen, and usually connected with their names, appears to have been first announced by John Phillips, in his "Geological Manual," and as a mere common sense deduction from the observed phenomena of volcanic action and the probable results of the gradual cooling of the earth § It receives striking confirmation from the observed succession of acidic and basic volcanic rocks of all geological periods and in all localities. It would even seem, from recent spectroscopic investigations of Lockyer, that there is evidence of a similar succession of magmas in the heavenly bodies, and the discovery of Nordenskiöld of native iron in Greenland basalts, affords a probability that the inner magma is in part metallic.*

(5) Where rents or fissures form in the upper crust, the material of the lower crust is forced upward by the pressure of the less supported portions of the former, giving rise to volcanic phenomena either of an explosive or quiet character, as may be determined by contact with water. The underlying material may also be carried to the surface by the agency of heated water, producing those quiet discharges which Hunt has named crenitic. It is to be observed here that explosive volcanic phenomena, and the formation of cones, are, as Prestwich has well remarked, characteristic of an old and thickened crust; quiet ejection from fissures and hydro-thermal action may have been more common in earlier periods and with a thinner over-crust.

(6.) The contraction of the earth's interior by cooling and by the emission of material from below the over-crust has caused this crust to press downward, and therefore laterially, and so to effect great bends, folds, and plications; and these modified subsequently by surface denudation constitute mountain chains and continental plateaus. As Hall long ago pointed out,† such lines of folding have been produced more especially where thick sediments had been laid down on the sea bottom. Thus we have here another apparent paradox, namely, that the elevations of the earth's crust occur in the places where the greatest burden of detritus has been laid down upon it, and where consequently the crust has been softened and depressed. We must beware, in this connection, of exaggerated notions of the extent of contraction and of crumpling required to form mountains. Bonney has well shown, in lectures delivered at the London Institution, that an amount of contraction, almost inappreciable in comparison with the diameter of the earth, would be sufficient; and that as the greatest mountain chains are less than $\frac{1}{800}$th of the earth's radius in height, they would on an artificial globe a foot in diameter be no more important than the slight inequalities that might result from the paper gores overlapping each other at the edges.

(7.) The crushing and sliding of the over-crust implied in these movements raise some serious questions of a physical character. One of these relates to the rapidity or slowness of such movements, and the consequent degree of intensity of the heat developed, as a possible cause of metamorphism of rocks. Another has reference to the possibility of changes in the equilibrium of the earth itself as resulting from local collapse and ridging. These questions in connection with the present dissociation of the axis of rotation from the magnetic poles, and with changes of climate, have attracted some attention,‡ and probably deserve further consideration on the part of physicists. In so far as geological evidence is concerned, it would seem that the general association of crumpling with metamorphism indicates a certain rapidity in the process of mountain-making, and consequent development of heat, and the arrangement of the older rocks around the Arctic basin forbids us from assuming any extensive movement of the axis of rotation though it does not exclude changes to a limited extent. I hope that Professor Darwin will discuss these points in his address to the Physical Section.

I wish to formulate these principles as distinctly as possible, and as the result of all the long series of observations, calculations, and discussions since the time of Werner and Hutton, and in which a vast number of able physicists and naturalists have borne a part, because they may be considered as certain deductions from our actual knowledge, and because they lie at the foundation of a rational physical geology.

We may popularise these deductions by comparing the earth to a drupe or stone-fruit, such as a plum or peach, somewhat dried up. It has a large and intensely hard stone and kernal, a thin pulp made up of two layers, an inner more dense and dark-coloured, and an outer less dense and lighter-coloured. These constitute the under-crust. On the outside it has a thin membrane or over-crust. In the process of drying it has slightly shrunk, so as to produce ridges and hollows of the outer crust, and this outer crust has cracked in some places, allowing portions of the pulp to ooze out—in some of these its lower dark substance, in others its upper and lighter material. The analogy extends no further, for there is nothing in our withered fruit to represent the oceans occupying the lower parts of the surface or the deposits which they have laid down.

(To be continued.)

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* Hopkins, Mallet, Sir William Thomson, and Prof. G. H. Darwin maintain the solidity and rigidity of the earth on astronomical grounds; but different conclusions have been reached by Hennesey, Delaunay, and Airy. In America Barnard and Crosby, Dutton, Le Conte, and Wadsworth have discussed these questions.

† An objection has been taken to the effect that the supposed ellipsoidal form of the equator is inconsistent with a plastic sub-crust. But this ellipsoidal form is not absolutely certain, or if it exists, is very minute. Bonney has in a recent lecture suggested the important consideration that a mass may be slowly mobile under long-continued pressure, while yet rigid with reference to more sudden movements.

‡ *Phil. Trans.*, 1884. Also Crosby in *Proc. Boston Soc. Nat. Hist.* 1883.

§ Phillips says("Manual of Geology," 1855, p. 493): "If we regard them (the internal crystalline rocks) as acquiring solidification by cooling in zones parallel to the surface, we should have sheets of granitic and basaltic rocks generated below, the first uppermost, the last undermost, while above the several strata were produced in a series beginning at the bottom. In this sense the rocks of fusion may be called with Lyell *hypogene*. Certainly under particular areas of country are found evidence of the liquefaction of one set of igneous products after the solidification of others. Many dykes of basalt traversing granite show themselves to have been in fusion after the solidification of the granite." In various forms Phillips returns to this idea, as at pp. 556 and 564, in that unpretending manner which was his wont. Dr. Sterry Hunt has kindly directed my attention to the fact of Phillips' right of priority in this matter. Durocher in 1857 elaborated the theory of magmas in the *Annales des Mines*, and we are indebted to Dutton, of the United States Geological Survey, for its detailed application to the remarkable volcanic outflows of Western America.

* These basalts occur at Ovifak, Greenland. Andrews has found small particles of iron in British basalts. Prestwich and Judd have referred to the bearing on general geology of these facts, and of Lockyer's suggestions.

† Hall (American Association Address, 1857, subsequently republished, with additions, as "Contributions to the Geological History of the American Continent," Mallet), Rogers, Dana, Le Conte, &c.

‡ See recent paper of Oldham and Fisher in *Geological Magazine* and *Philosophical Magazine*, July, 1886. Also Péroche, *Revol. Polaires*. Paris, 1886.

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ON ELECTROLYSIS.

BY PROF. OLIVER J. LODGE, D.SC.

(Continued from page 328.)

Modification of the above Table by the introduction of Kohlrausch's hypothesis that each ion has its own rate of travel.—Consider now what will happen if, instead of assuming that opposite corresponding ions must go at the same pace, we assume that each has its own pace; and that the sharing of the current between the ingredients of the fluid depends on these intrinsic ionic velocities and on the proportion of each substance present. Of the two compounds AC and A'C', we must affix a mass-velocity to each ion—say, α, γ, α', γ', respectively; so that

$\alpha+\gamma$ is what we formerly called λ,

and $\alpha'+\gamma'$,, ,, λ',

but no longer does $\alpha=\frac{1}{2}\lambda$. So the above table becomes :—

Results of Double Electrolysis, &c.

Substance.	Loss in cathode vessel.	Less in anode vessel.	Total loss.
A	α	$-\alpha$	0
A'	α'	$1-\alpha$	1
C	$1-\gamma$	γ	1
C'	$-\gamma$	γ'	0
AC	$1-\gamma$	γ	1
A'C'	α'	$1-\alpha'$	1
AC'	$-(\alpha'+\gamma')$	$-(\alpha+\gamma)$	-1

This gives the relative formation of free acid in the two vessels exactly the same as before, viz., $\frac{\alpha+\gamma}{\alpha'+\gamma'}=\frac{\lambda}{\lambda'}$

It is a trifle more general than the former hypothesis, in the non-equality of α and γ, and of α' and γ', and this fact may furnish a method of distinguishing between the two hypotheses.

From the table we see a way to find these values, thus :—

γ = loss of AC in the anode vessel,

α' = loss of A'C' in the cathode vessel,

$\alpha+\gamma$ = gain of AC' in the anode vessel,

and $\alpha+\gamma+\alpha'+\gamma'=1$.

In Kohlrausch's theory, indeed, ionic velocities are supposed to be pretty well known, and accordingly we may seek to compare the relative quantity of free acid, found in the two vessels, with the ratio $\frac{\alpha+\gamma}{\alpha'+\gamma'}$

But, then, Kohlrausch's velocity-numbers are founded on a strictly Hittorfian view of migration, and do not depend on the assumed conductivity of all the ingredients present in a fluid; they are intended to stand for the actual speed of moving salt atoms, and the water atoms are neglected. Kohlrausch's numbers are, in fact, totally different things from our α, γ, α', γ', which include along with the idea of velocity the idea of amount of substance available for conducting the current. In terms of a notation to be used later, $\frac{\alpha+\gamma}{\alpha'+\gamma'}=\frac{N_1 a_1}{N_2 a_2}$.

Generalisation of the above, to suit the case when a mixture of ions may be given off at each electrode.—If we now extend our view a little to cover cases (1), (2), and (3) at the same time—that is, to take account of a possible *mixture* of liberated ions, such as one frequently gets with intense currents, and may get at any time, we must write the actual amount of liberated cations c and c', and of anions a and a', where, of course, $c+c'=\alpha+\alpha'=1$; and the table becomes the following :—

Results of Double Electrolysis, &c.

Substance.	Amount of substance lost by cathode vessel.	Amount of substance lost by anode vessel.	Total loss.
A	a	$\alpha\ \alpha$	α
A'	α'	$\alpha'-\alpha'$	α'
C	$c-\gamma$	γ	c
C'	$c'-\gamma'$	γ'	c'
AC	$(c-\gamma)$ or (a)	(γ) or $(\alpha-a)$	(c) or (a)
A'C'	(a') or $(c'-\gamma')$	$(a'-\alpha')$ or (γ')	(α') or (c')
AC'	$(\alpha+\gamma)-c$	$a-(\alpha+\gamma)$	$(a-c)$
A'C	or $c-(\alpha+\gamma)$	or $(\alpha+\gamma)-a$	or $(c-a)$

This table looks more complex than the others because it contains alternatives; they are not ambiguities, and it is easy enough to know in any particular case which is the right alternative, but it cannot be expressed by the general symbols, because it is impossible to know whether $c-\gamma$ or a is going to be the bigger. The rule is that the bigger of the two alternatives about the loss of AC and A'C' is the true one; and the substance formed will be at the same time decided by the values which in the last two alternative lines come out negative. Or take it conversely. Suppose A'C is the substance formed in both vessels as the bye-product, then the second set of alternatives are the right ones all through; but if AC' is the substance formed in both vessels, the first set of alternatives are correct; while, if it should happen that AC' is formed in the anode vessel and A'C in the cathode, then the first set of alternatives are true for the anode vessel and the second set for the cathode vessel. With actual chemical substances it is usually easy to see whether the bye-product will be AC' or A'C, and thus to fix the alternatives. Thus, with a solution of copper sulphate, it is plain that the bye-product will be H_2SO_4 in both vessels, and not CuO.*

As an illustration of the possibility just mentioned, about the bye-products being different in the two vessels, consider the electrolysis of a salt of some metal more electropositive than hydrogen—for instance, Glauber's salts. Neither Na nor SO_4 can be liberated—the liberated ions must be H and O; but the water is not merely primarily decomposed, Na_2SO_4 shares in the conduction of the current, and accordingly secondary actions go on, forming acid at anode and alkali at cathode, as is perfectly well known. The last table gives every detail of the action, and points out that in order to determine experimentally how much of the current is conveyed by the salt and how much by the water, we have only to measure either the amount of acid or the amount of alkali produced. For in this case $\alpha'=c'=1$; $\alpha=c=0$; the production of acid is $\alpha+\gamma=\lambda$, the proportion of the current conveyed by the salt; and the production of alkali is precisely equivalent.

General Theory of Multiple Electrolysis.—It is now only a matter of writing to make a table for the most general case of electrolysis of a single liquid containing any number of substances. It is not much use now excluding double decomposition, and we will begin by letting the liberated ions be the most complicated mixture possible. Mix together the substances $A_1C_1+A_2C_2+\ldots+A_nC_n$; the result of the mixing is that each anion is liable to be combined with all the cations forming $A_1C_1+A_1C_2+\ldots$, and so on for the others; say, $A_1\Sigma C+A_2\Sigma C+\ldots$; or altogether $\Sigma A.\Sigma C$.

Let the liberated ions be $a_1, a_2 \ldots a_n$, equivalent of $A_1, A_2, \ldots$ &c. and $c_1, c_2, \ldots c_n$, equivalents of $C_1, C_2 \ldots$, &c., respectively. Let the mass-velocities of the independent ions be

$a_1, a_2, \ldots a_n$ for the anions,

and $\gamma_1, \gamma_2, \ldots \gamma_n$ for the cations.

Then the following equations hold among the quantities :—

$$\Sigma a=\Sigma c=1,$$

$$\Sigma a+\Sigma\gamma=1;$$

and, if it is worth while attempting to specify how much of the current each substance conveys,

$a_1+\gamma_1=\lambda_1$; $a_2+\gamma_2=\lambda_2$; . . ., &c.

[Further, if my notion is true that an electric current necessarily consists of equal positive and negative currents, $\Sigma a=\Sigma\gamma$. I even venture to think it *probable* that $a_1=\gamma_1$, $a_2=\gamma_2$, &c. See below.]

Now the portion of above table referring to the loss of elements is simple enough :—

Element.	Amount lost in cathode vessel.	Amount lost in anode vessel.
A_1	a_1	a_1-a_1
A_2	a_2	a_2-a_2
⋮	⋮	⋮
C_1	$c_1-\gamma_1$	γ_1
C_2	$c_2-\gamma_2$	γ_2
⋮	⋮	⋮

But when you come to the compounds there is no definiteness; by reason of the double decomposition which has gone on. Moreover, there are the apparent alternatives, just as in the last table. To get rid of alternatives, decide that the liberated ions are single, one anion A_k, and one cation C_l, where k and l may be equal as a special case. Then the proportion of the table referring to loss of compound is :—

Original substance.	Lost in cathode vessel.	Lost in anode vessel.	Total loss.
$A_1(\Sigma C-C_l)$	a_1	$-a_1$	0
$A_2(\Sigma C-C_l)$	a_2	$-a_2$	0
⋮	⋮	⋮	⋮
$A_k(\Sigma C-C_l)$	a_k	$1-a_k$	1
⋮	⋮	⋮	⋮
$A_n(\Sigma C-C_l)$	a_n	$-a_n$	0
$C_l(\Sigma A-A_k)$	$1-\gamma_l$	γ_l	1

If no double decomposition had gone on, the substances would have simply been A_1C_1, A_2C_2, &c. The meaning of $A_1(\Sigma C-C_l)$ is: all the compounds into which A_1 happens to enter, with the express exclusion of

* Remember that the electrodes are supposed to be platinum, so that oxygen is liberated; with a *copper* anode it is easy enough to form CuO as has already been said.

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A_1C_l, this being considered separately, along with A_2C_l, A_3C_l, . . ., &c., in the last line of the table.

The remainder of the table, dealing with the secondary or bye-products formed, is too indeterminate to be instructive; for even if double decomposition had been excluded originally, it must be supposed to occur now, and the substances formed can only be written:—

Substance formed in cathode vessel.	Amount.	Substance formed in anode vessel.	Amount.
$A_1(\Sigma C - C_1 - C_l)$	$a_1+\gamma_1$	$C_1(\Sigma A - A_1 - A_k)$	$a_1+\gamma_1$
$A_2(\Sigma C - C_2 - C_l)$	$a_2+\gamma_2$	$C_2(\Sigma A - A_2 - A_k)$	$a_2+\gamma_2$
. . . . .	. . .	. . . . .	. . .
$A_l(\Sigma C - C_l)$	$1-(a_l+\gamma_l)$	$C_k(\Sigma A - A_k)$	$1-(a_k+\gamma_k)$
. . . . .	. . .	. . . . .	. . .
$A_n(\Sigma C - C_n)$	$a_n+\gamma_n$	$C_n(\Sigma A - A_n - A_k)$	$a_n+\gamma_n$

where A_1 ($\Sigma C - C_1 - C_3$) stands for $A_1C_2 + A_1C_4 + A_1C_5 + . . .$, or any of them—*i.e.*, for all the possible new combinations of A_1 with cations; the C_1 being excluded because A_1C_1 is certainly not a new compound; and C_l being excluded because, being the cation deposited on the electrode, there is bound to be a deficiency of it rather than an excess, unless, indeed, more is brought over by migration than is deposited. Cases of even this anomaly were discovered by Hittorf among the iodides and chlorides of zinc and cadmium, especially when dissolved in alcohol; more than one equivalent of iodine is carried over toward anode, as much indeed, in one case, as two equivalents. This, however, is regarded as exceptional by everybody, and is usually explained by supposing a sub-salt to travel bodily with the simple ion thus: $3CdI_2 = CD + (2CdI + 2I_2)$, where the quantity in brackets may be the true anion. The same idea has been extended to other and more ordinary cases.

Objections to the idea of unequal velocities of anions and cations.—The bare notion of unequal molecular velocity has received considerable and important development at the hands of Quincke, Wiedemann, and Kohlrausch; but they all accept the fact, and suggest modes for accounting for it. We will therefore defer consideration of their theories to a later head. What I wish to point out is that migration data afford no *proof* that ions travel at unequal rates, because the facts can be accounted for without any such assumption, as has been shown at length; but if I have to state what objection I feel towards considering the anion and cation velocity unequal, I can only answer in an unsatisfactory manner as follows:—1st. Electricity is known to obey the laws of an incompressible fluid; and whether for positive electricity or for negative electricity, this is equally true. It may well be that electricity is far from being such a fluid, or pair of fluids, but there must be some analogy or they would not obey so exactly the same equations. If one allows mental images of electric actions, the guise of an incompressible, indestructible, uncreatable fluid, always flowing in closed circuits, naturally suggests itself for either kind of electricity. Equal quantities of opposite kinds in coincidence do indeed neutralise all electrostatic effect, but one does not conceive of their annihilating each other. 2nd. In certain cases an electric current is *known* to consist of equal opposite streams of positive and negative electricity. In a simple binary (fused) electrolyte this is so (see above); and in the convection portion of the circuit of a Holtz machine it is so.

If provisionally these lemmas be granted, the argument is obvious. Include one or other such arrangement for insuring equal opposite flow in any circuit, along with many kinds of voltameters. Can one think of unequal rates of flow of opposite electricities in one part of a circuit and equal rates of flow in another? Not unless it is possible for equal streams of opposite electricities to meet and annihilate each other. And if we can thus control and make equal the electric streams without affecting phenomena in the slightest, must they not always be equal? And it is plain that equality of the electric streams renders necessary the equal speed of anion and cation, since by Faraday's laws atomic charge is constant. Not, indeed, that this rigidly requires that *each* anion should travel at the same rate as its corresponding cation, or that $a_1=\gamma_1$, $a_2=\gamma_2$, &c. All is satisfied if the anions *as a whole* travel as quick as the cations as a whole—*i.e.*, if $\Sigma a = \Sigma\gamma$; but it is difficult to think of the relations as being always satisfied unless each individual a equals each individual γ: the same kind of argument as that which leads one to "equate coefficients." But less rigorous! Granted. I do not pretend that any of this is a rigorous argument; it is little better than a statement of prejudice with an attempt at justification.

To see if any definite and unambiguous experimental answer can be obtained to the question, "At what rate do ions travel?" I propose to try a modification of those old experiments with electrolytes in series, where a precipitate is formed in the middle one of three vessels. For instance, use $BaCl_2$ in the anode vessel, Na_2SO_4 in the cathode vessel, and in the intermediate vessel, which is to be in the form of a long tube, dilute HCl. Then pass a current, and observe whereabouts, how soon, and with what appearances, the precipitate shows itself. Innumerable similar experiments suggest themselves, but it is needless to specify any more of them at present.

III.—Quantitative Laws of Electrolysis.

The main laws known at the present time concerning the passage of electricity through liquids may be denominated, (*a*) Ohm's or Kholrausch's (*b*) Faraday's two laws, (*c*) Joule's, or Helmholt's, or Thomson's laws.

(a) Ohm's Law of Electrolytic Conduction.—The researches of Kohlrausch and Nippoldt, and several others, give us very good grounds for asserting that, in all ordinary cases of electrolytic conjunction, Ohm's law is at least approximately obeyed; currents being proportional to E.M.F. actually applied to the liquid. It is exceedingly important to test this law in liquids with the utmost accuracy, as has been done for metals by a British Association Committee (Maxwell and Chrystal), but the research would be a very difficult one. We have seen reason for guessing that with violent currents the law may perhaps begin to fail, even if it be exact for weak currents; but on Maxwell's theory of light it can hardly be quite exact for any current, because the optical transparency of electrolytes shows that they behave as dielectrics to very rapidly alternating E.M.F.'s. But the law is very nearly true any way, and this fact of itself is important, as showing that infinitesimal E.M.F.'s can produce a current. Now, if there were any chemical cling between the atoms taking part in conduction this could not be—a finite E.M.F. would be needed to tear them asunder; and this is what physicists mean by using the term "dissociation" in this connection. The atoms are so free of one another that they must be either really or virtually dissociated. Not all the molecules of the compound need be in this condition, of course, only a certain percentage of them, and the conductivity of the liquid must depend upon the value of this percentage. It may be supposed nil in a perfectly pure homogeneous liquid like H_2O; it may be supposed to be caused by the presence of foreign molecules (*e.g.*, of salt or acid); and it may be supposed to increase with rise of temperature.

The transparency of an electrolyte may, however, be explained without assuming any violation of Ohm's law, by supposing that the percentage of dissociated atoms is too small to perceptibly affect the properties of the liquid in bulk. On this hypothesis, rise of temperature, or other mode of increasing conductivity, might perhaps cause some increase in opacity; moreover, it is to be remembered that the transparency of electrolytes for long waves is possibly very small.

(b) Faraday's Two Laws.—(1) The voltametric law. (2) The law of electro-chemical equivalence.

Law 1 asserts that the amount of electro-chemical decomposition is a precise measure of the amount of electricity conveyed; *i.e.*, that no electrolyte for which the law is true possesses a trace of metallic conductivity; or, that electrolytic conduction and chemical decomposition are precisely correlative. The law has been most exactly verified for nitrate of silver solution by Lord Rayleigh; for this substance, therefore, we know that it is true to a high degree of accuracy. For other substances our knowledge is at present only approximate, the main difficulty in its verification lying in the prevalence of secondary actions and the confusion they cause. So great is the influence of these actions that in some cases an electrolyte has been asserted to conduct only metallically, and not to be decomposed at all. This has been said, for instance, of the fused iodide and chloride of mercury. A strong current may be sent through these fused salts with carbon electrodes and no products of decomposition shall appear, because they dissolve and diffuse through the liquid with such suprising velocity. J. W. Clark* has proved this to be the explanation, and has succeeded in getting off a good supply of mercury, and of iodine and chlorine, by separating the electrodes by a sufficiency of intervening porous material, which, whether it retard true diffusion or not, certainly hinders convection. But, of course, such an experiment has not exact quantitative signification until every trace of recomposition is avoided, and the theoretical amount of free ions obtained. And this is just the difficulty; for even in simple acid water, if any air be dissolved in the water it is well known that an insufficient supply of hydrogen comes off, while if the water is *not* saturated with oxygen, the supply of oxygen must be deficient by reason of solution. If oxygen be estimated by *volume* it will be apparently deficient for another reason; but the better way of estimating it is by loss of weight, which gets over the ozone difficulty. Helmholtz has taught us how to get over the dissolved air difficulty, by making a most ingenious air-free cell, described in the Faraday Lecture, 1881; and he shows that in such a cell polarisation is produced by infinitesimal currents, and no permanent leak goes on through the cell until the applied E.M.F. attains a certain value. This is a perfectly valid proof that no trace of metallic conduction exists in air-free acid-water, and that accordingly for this substance Faraday's law 1 is true.

We have already expressed the law in several forms of words. Helmholtz expresses it as follows: "Through each section of an electrolytic conductor we have always equivalent electrical and chemical motion." And if this fact of equivalent electrical and chemical motion be expressed, as Ampère very naturally expressed it, by calling it a convection of electricity by the moving atoms of matter, we may state Faraday's law 1 thus: —*Electrolysis is a kind of electrical convection rather than conduction, each atom carrying a charge with it; and the charge conveyed by every atom of a given substance is the same.* Obviously a vitally important statement if the slight amount of hypothesis involved in it is legitimate, as I fully believe it to be; and it is the one virtually adopted by Clerk Maxwell in his treatise.

Law 2 asserts that when a current is sent through a series of different substances, the mass of each substance liberated (or decomposed, or dissolved, or whatever it is that happens to it) is proportional to its ordinary chemical equivalence: or, that the amount of any substance acted upon during the passage of a given quantity of electricity is equal to its molecular weight divided by its atomicity, or, more explicitly, its molecular weight divided by the number of bonds which under the particular circumstances happen to be loosed or joined, per molecule of that substance, be it element or be it compound. Evidence for the truth of this law has been accumulated by Daniell and Miller, by Wiedemann, Hittorf, Matteucci, Becquerel, Soret, and Buff. They all separate the anode from the cathode vessel by various devices, and it appears as if the more carefully secondary actions are prevented or allowed for, the more nearly is the law true. It may be sufficient to refer to Wiedemann's "Elecktricität" for an account of a mass of research. Further evidence may be

* *Phil. Mag.*, November, 1885.

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suggested as given by the behaviour of certain electrolytes in series contact, without electrodes intervening, after the manner of Davy; for, if two meeting ions were not precisely equivalent, the one in excess would have to appear in a solitary state. Such a phenomenon might be well looked for, but it has never yet been certainly observed. The physical import of law 2 is that it extends the statement of law 1, about each atom in a single substance having the same definite electric charge, to all electrolytes, and enables us to conclude that a definite quantity of electricity belongs to each unit of affinity of every atom of whatever kind; in other words, that every monad atom or radicle (while being liberated on an electrode, at any rate) has associated with it a certain definite quantity of electricity, no matter from what compound it is being liberated, and no matter what the name of the radicle itself may be; that every dyad radicle has twice this quantity associated with it, every triad three times as much, and so on.

It is impossible to overlook the immense interest of such statements as these to any chemist wishing to grasp the real meaning of chemical combination and affinity. But the tremendous import of the law to physicists also may be more vividly indicated by pointing out that the electric charge of a nascent monad atom is a kind of natural unit of electric quantity, *and that fractional portions of such units are*, in electrolysis at least, *unknown*. One may have integral multiples of this natural unit, as in dyads and triads, but one cannot have submultiples, until chemists discover some quantivalence less than that of hydrogen, or rather until they see reason to abandon the idea that quantivalence proceeds by integers (the basis of their "atomic theory") altogether. Maxwell no doubt intends to call attention to the superlative interest of the fact that there appears to be a non-divisible electrical unit, when he calls it "a molecule (his customary cautious name, intended to include atoms also if they exist) of electricity." And Helmholtz does not shrink from staring the possibility in the face that electricity may turn out to be as "atomic" as matter.

Atomic Idea of Electricity; Electrostatic Theory of Chemistry.—Let us first consider what is really the evidence for such a view. Electricity is found to associate itself with the atoms of matter in multiples of one fundamental quantity, but never in fractions of it; it does not then follow that fractions of this quantity are impossible, but it may well be that we have never yet dwelt with them. The evidence for the atomic nature of electricity is pretty much of the same nature as that for the atomic nature of matter. Gains and losses of electricity are apparently continuous, but so they are of matter; all that is necessary to satisfy experience is for the atom of electricity to be smaller than any quantity hitherto measured. Whether the charge of a monad atom be indivisible or not, it is certainly a natural unit of electricity, and it becomes of great interest to calculate its value. This is easily possible to the same degree of approximation, as we know the size of an atom. The electrical charges in the atoms of a gramme of water are known accurately enough, from ordinary electro-chemical-equivalent determinations, viz., $1{\cdot}5\times10^{13}$ electrostatic units of each kind; the number of molecules in a gramme of water may be considered as something between 10^{24} and 10^{25}; and accordingly the charge of a monad atom is something like 10^{-11} 10^{-12} electrostatic units. Now this is very small, less than the hundred trillionth of a coulomb, and if it were really an ultimate atom of electricity, it is wholly unlikely that the fact would have been noticed. It is possible, however, to think of some phenomena which may afford an indication one way or the other, and I shall venture to suggest one or two later. The charge of an atom is so small that its potential cannot turn out high, on any customary hypothesis as to actual atomic magnitude, provided ordinary considerations of electrostatics apply to atoms. It is difficult to know whether they apply or not until it can be shown that absolute vacuum has a specific inductive capacity. The transparency of interstellar space, and the velocity of radiation in it, would seem respectively to answer the question in the affirmative, and to suggest unity as its value. At any rate, when one has no other mode of tackling atomic charges it would seem reasonable to try the ordinary electrostatic laws on them, and see how they fit and what happens. Consider, therefore, the following problem. A number of equal spheres, each charged with a definite quantity of electricity, are commingled with the same number of similar spheres, each charged with the same quantity of opposite electricity, the potentials of the spheres being so low that mutual discharge does not occur even during a collision, or so-called "contact," of the spheres, and some law of force being assumed between the spheres irrespective of their charges. I do not propose to attack the problem thus vaguely suggested, because many persons can do it far more easily and thoroughly than I; but certain facts are patent. The potential of each sphere must be lower in the "combined" state than in the isolated, and, unless an atom be assumed to be extravagantly small compared with the spaces between them in the liquid state, the potential of each isolated atom is but a few volts.

Facts are known which suggest sizes for the actual substance of the molecules, but, without pressing them, one may assume that whereas in the liquid state the distance of the atoms apart is about 10^{-8}, the radius of each of them is about 10^{-9} or even 10^{-10} centimetres; then, the charge of a monad atom being as aforesaid 10^{-11} or 10^{-12}, it follows that its potential, when isolated, is about 3 volts. If such an atom pair off with another of opposite sign, the potential of each will fall as they approach; becoming, when the distance between their nearest points is one-tenth the radius of either, about 1·2 volts,* and falling asymptotically to zero as the distance between them still further diminishes.† It is true that this fall of potential has not the result of postponing mutual discharge *ad infinitum* however near items may approach; but I feel constrained to believe that no such discharge ever in practice occurs, from the fact (if it be a fact) that the whole of a liquid can be electrolysed away, and from the assumption that any such discharged molecules would be wholly intractable to electrical influence. To explain non-discharge we can fall back on the rather dark fact of the enormous apparent dielectric strength of vacuum, combined with the very low potentials to which atoms are charged.

I have tried an experiment of electrifying two falling clouds of lycopodium oppositely, and allowing them to mix, or, so to speak, combine. The result has not yet been satisfactory, but lycopodium granules are coarse and weighty bodies, and are unwieldy representatives of atoms. To get anything like such a quantity of each kind of electricity into the grains of a cubic millimetre of lycopodium as exists in the atoms of a cubic millimetre of water, the charge, and therefore the potential, of each granule would have to be enormous, something like a billion volts: for I find the diameter of a lycopodium granule about ·004 centimetre. It is easy to see that a given quantity of both kinds of electricity, shared among a given bulk of equal and definitely arranged spheres, will raise the potential of each by an amount proportional to its superfices. It may be noted, as interestingly showing the enormous charges which, distributed among the atoms of a substance, produce such an insignificant potential, *i.e.*, as illustrating the prodigious electrical capacity of molecular arrangement, that if the opposite electricities were extracted from a milligramme of water, and given to two spheres one mile apart, those two spheres would attract each other with a force of ten tons!*—(Cf. Helmholtz, Faraday Lecture, 1881.)

A more hopeful substance than lycopodium, for constructing an artificial chemical compound with, is fine smoke, say of magnesia, which hovers in air for a long time. But, as Clark and I have observed, it is sufficient to electrify such smoke with only one kind of electricity in order to cause the particles to combine or coagulate together—doubtless because of minute differences of potential between them; the aggregations soon becoming very large and giving the appearance of snow. I now fancy that this same phenomenon of aggregation may go on among the atoms of a gas when it is electrified, and may account for the formation of ozone near an electric machine, for the formation of ammonia from nitrogen and hydrogen, and such like.

(c) Joule's or Helmholtz's or Thomson's law of the dependence of Decomposition E.M.F. on Chemical Combination-energy.—The deduction of this law from the first law of thermodynamics may be exhibited perhaps most clearly and briefly as follows:—

(i.) Definition of E.M.F. as—the work done in a circuit per unit of electricity conveyed, or $E=W/Q$.

(ii.) Definition of Electro-chemical Equivalent as—the mass of substance decomposed per unit of electricity conveyed, or $\epsilon=m/Q$

(iii.) Definition of Thermal Equivalent as—the heat set free during the formation of one gramme of the substance from the two radicles into which it has just been supposed to be decomposed, provided that none of the energy remains in some form other than that of heat, $\theta=H/m$.

(iv.) Statement of the first law of thermodynamics applied to the electrical decomposition of the said substance in the given way, on the assumption that the whole of the work done by a current is expended in decomposing the substance,

$$W=JH.$$

The simple algebraic consequence of these four equations is

$$E=J\epsilon\theta,$$

which is shorthand for the law, and may be read thus:—the E.M.F needed to decompose a substance into given constituents is calculable by simple energy considerations from purely thermo-chemical data.

If θ'' stands for the heat production per dyad gramme-equivalent of the substance (*e.g.*, per 18 grammes of water, 98 grammes of sulphuric acid, or 136 grammes of chloride of zinc), it is easy to see that

$$E=\frac{\theta''}{46{,}000}\text{ volts};$$

for $J=42\times10^6$, $\epsilon=\frac{\mu}{9{,}660\,k}$, $\theta''=\frac{2\mu\theta}{k}$, where μ is the molecular weight of the substance as compared with an atom of hydrogen, and k is the atomicity or number of bonds loosed in the decomposition supposed. Values of θ'' are tabulated direct by Julius Thomsen for a great variety of substances, and are quoted in Naumann's "Chemie," vol. i., and also

* See table by Sir William Thomson in "Electrostatics and Magnetism," sec. 142.

† Or one might work the argument conversely, and perhaps more plausibly, so as to obtain an estimate of atomic, as distinct from molecular, dimensions. Thus:—The total charge shared among the atoms of a gramme of water is perfectly well known, viz, 1,073 electro-magnetic units of each kind. The heat produced during the formation of a gramme of liquid water from its gaseous constituents is, according to J. Thomsen, 4,333 thermal units. If two bodies, or sets of bodies, each charged with that quantity of electricity (one set positive, the other set negative), approach each other so as to do this amount of work, their difference of potential must diminish, during the approach, by 1·7 volts. The fall may be from 1·7 to nearly 0, as the dissociation idea of electrolysis would suggest. Or it may be from 3 to 1·3, as the guess at atomic dimensions in the above text implies. Or atomic charge may be a thing acquired during the act of combination, as the hypothesis of zero charge in a molecular aggregate like HH or OO would imply; in which case the necessary fall of potential must be 3·4 volts. The first of these alternatives gives for the diameter of an oxgen atom $5{\cdot}6\times10^{15}x^3$; $1/x^3$ being the number of molecules in a gramme of water.

* If any cause could make the positive atoms in a drop of water group together and face the negative across a vacuum, a furious Leyden-jar, or "Globe-Lightning," would be produced.

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partly in Watt's "Dictionary of Chemistry"; hence the obtaining of the volts needed to decompose a substance, by simply dividing $6''$ by 46,000, is extremely convenient.

(To be continued.)

VISIT TO THE WORKS OF THE ANGLO-AMERICAN BRUSH CORPORATION.

In connection with the summer meeting of the Institution of Mechanical Engineers a party of engineers, many of whom were from the Continent, visited the above works on the 18th August, and were shown the various operations and processes connected with the manufacture of electrical apparatus of various kinds.

In the fitting and erecting shop, amongst other things, they examined Brush and Victoria armature cores, of old and of recent designs, which were being made by special core winding and other machines.

The commutators and collectors of Brush and Victoria dynamos also engaged the attention of the visitors, who seemed much interested in the details and construction of these important parts of dynamo machines. Having inspected the very fine tools used in the fitting shop and the work of erecting the dynamos, a visit was made to the dynamo shed, where the machines used for lighting the shops and offices and for supplying current for various manufacturing operations were seen at work. Amongst these was running the old Brush No. 8 dynamo used so many years for the City lighting, which, it may be remembered, has always been operated from the Lambeth Works of the Brush Corporation. This dynamo has been fitted with one of the improved armatures, enabling it to supply about 60 arcs in series. Connected with it is a Brush automatic regulator for maintaing a constant current. The lamps in the shops and on the testing racks are all on the circuit of this machine, and are switched on and off as required, the power absorbed by the automatically-controlled dynamo being sensibly proportional to the number of lamps in operation.

In the winding shop were inspected the operation of winding armatures, field-magnets, electro-magnets, for arc lamps and for various instruments; and in the lamp-fitting shop the lighter operations of making arc lamps of various kinds, electric light fittings, electroliers, switches, switch-boards, and projectors.

In the testing room the visitors saw several projectors, with automatic and hand-fed lamps, Brush dynamos of various sizes, automatic regulators, arc lamps, including a Brush focussing or head-light lamp in an apparatus showing an image of the arc magnified about 100 times.

The multiple series or group lighting system for incandescent lamps was explained, and a safety device was seen in operation which placed spare lamps in circuit in case of breakage, and, if necessary, afterwards short-circuited the group.

Several Victoria dynamos were running, supplying power for projectors, for incandescent lamps, and for Victoria motors driving a circular saw and a ventilating fan.

The visitors seemed much interested in a Wimshurst machine giving a constant succession of vivid sparks.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Sept. 1.		Business Done Week Ending Sept. 1. Highest.		Lowest.	
Anglo-American	33,	34	..... 33½	.....	—	
Do. Preferred	55,	56	..... 55¾	.....	55	
Do. Deferred	11,	11½	..... 11 1-16	.....	—	
Brazilian Submarine	10⅜,	10⅞	..... 10¾	.....	10 9-16	
Cuba	11,	11½	..... 11⅜	.....	11¼	
Do. Preference	18,	19	..... —	.....	—	
Direct Spanish	1½,	2	..... —	.....	—	
Do. Preference	9,	10	..... —	.....	—	
Direct United States Cable	8⅞,	9½	 9	.....	8⅞	
Eastern Telegraph	11⅜,	11⅝	..... 11½	.....	11 5-16	
Do. 6 per Cent. Preference	14½,	14⅞	..... 14¾	.....	—	
Do. 5 per Cent. Debentures, 1899	105,	108	..... —	.....	—	
Eastern Extension	12⅜,	12⅝	..... 12 9-16	.....	12⅜	
German Union	9½,	9¾	..... 9¾	.....	—	
Globe Telegraph and Trust	6½,	6¾	..... 6 7-16	.....	6¼	
Do. Preference	13½,	13⅝	..... 13 5-16	.....	13	
Great Northern	12⅞,	13¼	 13	.....	12⅞	
Indo-European	36½,	37½	..... 37¼	.....	36	
Reuter's	6¾,	7	..... 6⅞	.....	—	
Submarine	195,	205	 190	.....	198	
West India and Panama	⅝,	¾	..... —	.....	—	
Do. 1st Preference	8⅞,	9¼	..... 8¾	.....	—	
Western Brazilian	6⅞,	7	..... —	.....	—	
Western Union 7 per Cent. 1st Mortgage	118,	122	..... 120⅝	.....	—	
Do. 6 per Cent. Sterling Bonds	104,	106	..... —	.....	—	

TELEPHONES.

Consolid. Telephone and Maintenance	13-16	15-16	.....	—	.....	—
Oriental	3-16	5-16	.....	—	.....	—
United Telephone	13⅜,	13⅞	.....	13⅞	.....	13⅞

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	2,	2½	.....	—	.....	—
Do. (fully paid)	3¾,	4¼	.....	—	.....	—
Swan	¾,	1⅛	.....	—	.....	—
Maxim Weston	3-16	5-16	.....	—	.....	—

MISCELLANEOUS.

Telegraph Construction	38	39	.....	38⅛	.....	—
India Rubber, Gutta Percha, and Telegraph Works	23½	24½	.....	24½	.....	23¾

NEWCASTLE-UPON-TYNE MINING, ENGINEERING, AND INDUSTRIAL EXHIBITION (INTERNATIONAL AND COLONIAL).

ROYAL JUBILEE YEAR, 1887.

PATRON—HIS GRACE THE DUKE OF NORTHUMBERLAND, K.G.
PRESIDENT—THE RIGHT HON. THE EARL OF RAVENSWORTH.
CHAIRMAN OF COUNCIL—JOHN DAGLISH, ESQ.

An International and Colonial EXHIBITION of INDUSTRIES, MANUFACTURES, and PRODUCTS will be opened in Newcastle-upon-Tyne on the 24th May, 1887.

Amongst other important Industries and Manufactures which will be represented are Coal and Mining, Shipbuilding, Ordnance, Marine, and other Engine works, Iron and Steel Works, Lead Works, Chemical Manufactures, and many others.

The attention of intending Exhibitors in the above Exhibition is drawn to the published Regulations of the Executive Council, which enact that all applications for space for Exhibits must be sent in on or before the 1st October, 1886.

It is important that this Regulation should be observed in order that the required spaces may be allotted.

By Order of the Executive Council,
JOHN H. AMOS, Honorary Secretary.

Exhibition, 23rd August, 1886.

JOURNAL OF THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

Edited by F. H. WEBB, Secretary.

No. 62, containing Papers on "LONG DISTANCE TELEPHONY," by W. H. PREECE, F.R.S.; "THE TELEPHONE as a RECEIVING INSTRUMENT in MILITARY TELEGRAPHY," by CAPTAIN P. CARDEW, R.E.; and "ON a PROBLEM relating to the ECONOMICAL ELECTROLYTIC DEPOSITION OF COPPER," by CAPTAIN H. R. SANKEY, R.E. With full report of the discussions arising thereon. Together with OTHER ORIGINAL COMMUNICATIONS and ABSTRACTS from various Scientific Periodicals, English and Foreign.
Price Three Shillings.

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Messrs. D. W. & Co. have supplied Provisions to the Stations of the Eastern and South African Telegraph Companies, and are prepared to execute orders on specially favourable terms at shortest notice

"THE ELECTRICIAN" SERIES.

NOW READY,

ELECTRO-CHEMISTRY. By G. GORE, F.R.S., Author of "The Art of Scientific Discovery," "The Art of Electro-Metallurgy," &c., &c.

This work possesses more of the character of a Dictionary than of a Text Book, in that it forms an almost complete reference to the original memoirs on this subject.
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NOTES.

ELECTRIC LIGHT IN SPAIN.—At San Sebastian the bull ring has been provided with a Brush installation.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 3rd inst. amounted to £3,235.

ANOTHER ELECTRIC LIGHTING STATION DESTROYED.—The electric lighting station at Hannibal, Montana, has been destroyed by a cyclone.

THE WEST COAST OF AMERICA TELEGRAPH COMPANY.—The gross earnings of this company for the month ending Aug. 31st were £3,105.

THE GAIETY THEATRE.—Messrs. E. L. Berry and Co. have received an order to light the Gaiety Theatre with 180 incandescent lamps three weeks from date of contract.

ELECTRICITY IN WARFARE.—The Russian Government has undertaken an extensive series of experiments on the employment of the telephone and also of the arc light for military purposes.

TELEPHONE TROUBLES.—A firm at Gresham House has issued a large type advertisement, notifying their withdrawal from the Telephone Exchange, "owing to the defective working of our telephone."

DIRECT SPANISH TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the month of August amounted to £1,370, against £1,326 in the corresponding period of last year.

THEATRE LIGHTING.—It is a singular fact—assuming the statement to be correct—that up to the present time there is only one theatre in the States in which the stage is provided with electric foot-lights.

GREECE.—The Department of Posts and Telegraphs in this country is to be completely re-organised. The number of telegraph offices now open is 128, the total number of lines being—overland 4,667 kilometres; submarine 3,775 kilometres.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending 3rd inst. were £2,535, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

QUERY.—The *Electrical World* says that Mobile, Alaska, "enjoys the distinction of being the only city in the world to go back to gas after having tried the electric light." Surely the London gas companies will not allow this statement to pass unchallenged.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic receipts of this company for August were £22,400, and the receipts for the period from 1st January to 31st August, £169,960; for the corresponding months in 1885 and 1884, £192,040 and £182,680 respectively.

TELEGRAPH CABLES INTERRUPTED.—The cables between Madras and Penang and between Rangoon and Penang are interrupted. It is not expected that these interruptions will be of long duration. Telegraphic communication is also interrupted with the Island of Mull.

USE OF WATER POWER IN AMERICA.—It is estimated that up to the present time not less than 14,000 horse-power, derived from water falls, is in use in the United States and Canada for driving dynamo machines. Nearly the whole of this power is employed for arc lights.

TELEPHONES AND TELEGRAPHS IN NEW ZEALAND.—Telephone exchanges now exist in seven different towns in New Zealand, with a total of 1,114 subscribers. The number of telegrams forwarded in 1884 was 1,600,000, which is no less than three per head of the population.

ELECTRIC LIGHT AT BARCELONA.—Comparative trials of gas and electricity are being carried out in the Paseo de Colon by the Municipality of Barcelona. Ninety-six arc lamps are in use, and in addition to this about 150 incandescents are supplied to shops in the same locality.

TELEPHONES AT THE BIRMINGHAM INDUSTRIAL EXHIBITION.—The National Telephone Company fitted up a temporary exchange at this Exhibition, making connection with the Birmingham Exchange and also with the trunk lines to Wolverhampton, Walsall, and Wednesbury.

CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this company during the month of August was 2,848, estimated to produce £2,200, against 2,833 messages, producing £2,262 in the corresponding month of last year. The traffic receipts for the month of May, estimated at £3,050, realised £3,103.

EDISON.—Edison has recently been interviewed by a New York reporter, to whom he made some observations upon the subject of earth currents. We are inclined to think, however, that it must have been the reporter and not Edison who has promised that before long earth currents will furnish the whole world with electricity for every required purpose.

CHURCH LIGHTING.—The problem of economically working a church lighting plant is solved in a very simple way at Oxford, Pa., where a storekeeper having put an installation of Thomson-Houston lights on his own premises, finds that it pays him very well to light the neighbouring church on Sunday evenings at a charge which is also considered satisfactory on the other side.

NEWCASTLE-ON-TYNE INTERNATIONAL EXHIBITION, 1887.—We would call the attention of electrical firms to the notice in our advertising columns which states that special attention will be given to electrical matters at this Exhibition, particularly with reference to the lighting and transmission of power in coal mines and ships. Applications for space must be made before 1st October.

PORTERAGE ON TELEGRAMS.—On Friday, September 3rd, Mr. Cochrane-Baillie asked the Postmaster-General whether he would take steps to reduce the porterage charged for telegrams delivered at a distance from a post office. The Postmaster-General replied that he did not see his way to make a less charge than 6d. per mile for a foot passenger, and 1s. per mile for a mounted messenger.

THE HASTINGS INSTALLATION.—At the last meeting of the Hastings Town Council it was resolved "That the existing contract with the Electric Light Company, for the lighting of the front from the Queen's Hotel to Warrior-square, by means of fifteen 2,000 nominal candle-power arc lamps, for the sum of £450 per annum, which expires on the 25th November, be renewed for another year."

MEDICAL ELECTRICITY.—The latest addition to appliances of this character consists of a small chloride of silver cell, measuring about 1½in. by 1in., and about the thickness of a shilling. It is intended to be worn inside the lining of a hat; two small silver plates connected with the terminals bear against the forehead. Thus equipped, we are assured that nervous headaches may be defied.

TELEPHONIC EXTENSION IN SCOTLAND.—The National Telephone Company have now completed the communication between Stirling, Alloa, and the Bridge of Allan. The lines between Stirling and Glasgow and between Stirling and

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Edinburgh are now in course of construction. It is also intended shortly to open communication between the districts of Glasgow and of Dundee, *via* Stirling.

THE LODYGUINE FILAMENT.—M. Lodyguine's process for obtaining carbon filaments of great tensile strength, to which we recently made some reference, is now said to consist in the treatment of the raw material with boric fluoride (BF_3). The reaction which takes place (and which proceeds in the cold) has the effect of expelling hydrogen from the organic carbon, whether it exists in a state of combination or otherwise.

MADRID TELEPHONE COMPANY.—A new telephone company for Madrid, the *Sociedad de Teléfonos de Madrid*, has been formed in Paris, under the auspices of the French Credit Mobilier and the International Telephone Company of Brussels. At the first general meeting recently held in Paris it was reported that 2,400 shares of 500f. each had been subscribed for, giving a share capital of 1,200,000f., say, £48,000, of which 125f. per share had been paid.

THE "VOLTA."—The electric launch "Volta," which has recently been completed at the works of Messrs. Stephens, Smith, and Co., Millwall, to the designs of Mr. A. Reckenzaun, left the West India Docks on Wednesday afternoon for Dover. Weather permitting, it is proposed to cross the Channel in her on Saturday next. Arrangements have been made to re-charge the cells at Dover. We hope shortly to give a full account of this boat and of its performance.

DUNDEE UNIVERSITY COLLEGE.—We have received a copy of the "Calendar of the University College of Dundee for the Fourth Session, 1886-7." We have previously called attention to the prominence given to physical science in the Dundee College. A special course extending over two years has been arranged in electrical engineering. Profs. Ewing and Steggall deliver the lectures and superintend the laboratory work in connection with these classes.

THE NEW YORK CONDUIT.—The cost of the concrete conduit which is being constructed for the telegraph and telephone wires in New York is estimated at $80,000. This sum is to be provided by an assessment of $4 per mile upon the wires of all the companies concerned. The Commissioners having decided upon the material of which the conduit is to be made, are now engaged in testing the tensile and crushing strength of various samples which have been submitted to them.

A GELATINE BATTERY.—Mr. Cox, of Cincinnati, has invented a battery. The zinc carbon plates are separated by gelatine containing acid. The arrangement seems to have some merit. We therefore regret that Mr. Cox should in one sentence claim to be the original inventor of this battery, on the ground that he has had one in use for eight months already, and should in the next sentence express his conviction that the battery "will last about ten years *without any attention whatever.*" (Mr. Cox's italics.)

A NEW ELECTRICAL CLOCK SYSTEM.—The Synchronous Time Company of Boston has introduced a new method of regulating clocks by electricity. The clocks to be controlled are connected by wire with a standard clock, and once every hour the latter closes a contact, and sends a current through the circuit. Each clock is provided with a regulating apparatus, which when traversed by the standard current acts upon the pendulum suspension in such a way as to increase or decrease its length accordingly as the clock has been running fast or slow.

"SPECIAL DELIVERY" LETTERS.—At Philadelphia the Postal Department has tried the experiment of a "special and immediate delivery" post. The idea was to compete with the local telegraph companies by organising a system for the immediate despatch of letters within a certain area, and on payment of a small extra fee, direct to their destination. The system has had a trial of nearly twelve months, and is now pronounced to be a failure. In October last year, when it first came into operation, nearly 12,000 letters were so delivered, but in July the number had fallen to 3,800, which was not a remunerative figure.

THE ELECTRIC LIGHT FOR LIGHTSHIPS.—On and after October 15 an experiment of an important nature is to be made upon the bar lightship at Liverpool, the Mersey Docks and Harbour Board having decided to exhibit tentatively an electric light instead of the present oil light. The new light, which has been fitted by Messrs. Crompton and Co., is to be visible at a distance of ten miles, and will show flashes every half minute from sunset to sunrise. Should it be necessary to discontinue the electric light, the oil light will be substituted. After the same date at the same lightship a powerful fog siren will be substituted for the present fog horn.

INDUSTRIAL EXHIBITION.—At the Polytechnic Institute, Regent-street, an Industrial Exhibition of work executed by members and students, was opened on the 1st inst. by Sir J. Lubbock. The hall has been lit by 60 Edison-Swan 16 candle-power lamps, run off an Edison dynamo driven by a 12 horse-power gas engine. An arc lamp is also employed, which is run from an "A" type Gramme machine. This installation has been erected by the students themselves. The exhibition comprises an extensive and interesting display of electrical apparatus, either the property of the Institute or of the students, or in some cases lent by certain of the electric lighting companies.

THE LANCASHIRE AND CHESHIRE TELEPHONE COMPANY.—We have received a copy of the list of subscribers to this company's Manchester exchanges, dated August, 1886. The list is well printed and well indexed, and contains a map of the extensive trunk line connections of this company, showing also the connection with the trunk lines of the Yorkshire Company. In the matter of call offices, trunk lines, and all other telephonic facilities, this district is far ahead of the metropolis. The mileage of wire has increased during the past year from 4,570 miles to 6,230, and the transmission of messages has now arrived at 11,000,000, at a cost of a small decimal over a penny per message.

THE ELECTRIC LIGHT IN BANKS, &c.—A number of banks, insurance offices, and other large establishments in London are being fitted up with the electric light, but in a very private manner. No published accounts can be given of these installations, as in many cases the owners object to their places being described. We understand that several London contractors are busily engaged in carrying out work of the above nature, where the electric light seems to be gaining great favour. The East and West India Dock Company's installation at Billiter-street, carried out by Messrs. R. E. Crompton and Co., seems to have been the starting point for many of these installations. We hope shortly to see a still larger number adopt this means of illumination.

TELEGRAPH CLERKS.—A well attended meeting of telegraphists was held at the Foresters' Hall on Wednesday evening. The greatest unanimity prevailed, and resolutions were passed expressing disappointment at the silence of the Government towards their petition, presented in March last, for increased remuneration, and deciding to call the new Postmaster-General's attention to the matter. It was also resolved in the event of no re-arrangement of their position being forthcoming, to use their best endeavours to draw public and parliamentary

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notice to their grievances, official agitation being declared hopeless. Every confidence in the committee was expressed, and a hearty vote of thanks was accorded to Mr. Pickersgill, M.P., for his attitude towards the telegraph clerks.

BOOKS RECEIVED.—We have received from Messrs. Mather and Platt a copy of their latest catalogue, containing full illustrated descriptions and price list of the well-known "Edison-Hopkinson" and "Manchester" dynamos, together with some well designed switch-boards and resistance frames.—Messrs. Goolden and Trotter send us a copy of their descriptive price list, which contains a very complete selection of requirements for installations of all kinds. We learn that this firm is about to introduce a new regulator for use in cases where it is necessary to run a dynamo from an unsteady engine.—From Messrs. Sampson Low and Co. we have received copies of "Analysis Tables for Chemical Students," by R. L. Taylor, and "Exercises in Mensuration," by T. W. Start.

ELECTRIC LIGHTING IN BOURNEMOUTH.—On Monday evening a number of the business men of the town met by invitation at the Tregonwell Arms Assembly Rooms to consider the introduction of electric lighting into Bournemouth, and to consider the advisability of forming a company for that purpose. Mr. Shepherd (of the firm of Mortimer, Shepherd, and Co., who have been giving electric lighting experiments in Bournemouth lately) stated the terms upon which he would undertake to light 500 incandescent lamps for shop purposes and also his terms for lighting 700 lamps. The following resolution was unanimously carried:—"That a sub-committee from the meeting be formed to canvass the town to see what support can be obtained for the purpose of using the electric light, and, secondly, in financing the experimental stage."

THE BEATTIE ELECTRO-MOTOR.—This motor possesses no special claim to novelty except in the method by which it is made self-regulating. The field-magnets, which are four in number, are each provided with several independent coils. The terminals of these coils are connected with a set of contact pieces, which are placed around the quadrant of a circle. An ordinary centrifugal governor is geared to the armature shaft, and this actuates a lever having a circular rack at its extremity. The latter moves a double contact switch, one end of which slides over the contact pieces connected with the field-magnet coils, and the other slides over a similar set connected to some resistance coils. In this way any increase of speed cuts out one or more of the field-magnet coils, and introduces resistance instead. The system is open to several very obvious objections.

THE LIGHTING OF MADRID.—We have several times referred to the conflict between the Madrid Gas Company and the trading community of Madrid with respect to the bad quality of the gas supplied and the high rates charged. The gas company has just issued its report for the past year, and it is somewhat surprising to find that while there has been a falling off of 12,000f. in the receipts, there has been an increase in the expenses of 60,000f. There was, consequently, a reduction in the dividend from 27½f. to 25f. The *Dia*, commenting upon the report, says "that the present year does not promise to be more satisfactory for the shareholders. The differences between the company and its customers is more pronounced, and in a short time we shall have part of Madrid illuminated by the electric light and a great number of the shops by petroleum."

THE EARTHQUAKE.—Earthquake shocks of diminished intensity continue to take place at frequent intervals in South Carolina, but not much additional damage has been done. The earthquake which inflicted so much injury in Greece upon the 27th ult. was also felt on the southern shore of the Mediterranean. In Lower Egypt three smart shocks were experienced, but little damage was done. Our French contemporary, the *Cosmos*, recently published a circumstantial account of an earthquake said to have been experienced in Normandy. The same issue in which this imaginary catastrophe is withdrawn from circulation contains the statement that earthquakes have "greatly multiplied" in England during the last few years. Whilst acknowledging that up to the present the inhabitants of this island have escaped lightly, the *Cosmos* fears that evil times are in store for us.

THE POSTMASTER-GENERAL AND THE TELEPHONE COMPANIES.—In the House of Commons on Wednesday evening, in reply to Mr. Gray, Mr. Raikes said, I have to state that I find the attention of the Department was called, in April last, to a statement of the managing director of the United Telephone Company that the company had made arrangements with certain railway companies to open telephone exchanges at all their stations. Thereupon, a letter was addressed to the United Telephone Company pointing out that such arrangements could not be carried out without the special consent of the Postmaster-General, the right of transacting telegraph business at the stations in question having been purchased by the State. The company replied that their chairman, vice-chairman, and managing director would come to the Post Office on an early date to discuss the matter. They have not yet done so, and, meanwhile, the Department has not allowed any call office to be established at railway stations.

PROPOSED INDUSTRIAL ELECTRICAL ASSOCIATION.—A circular has been issued signed by eight or nine of the leading electrical companies and firms, proposing the formation of an "Industrial Electrical Association for the Advancement of Electrical Engineering." The objects which this movement aims at will be gathered from the following extract:—"The duties of the association will be as follows—(1) To facilitate united action with regard to proceedings affecting the trade in Parliament and other public bodies. (2) To hold periodical meetings to discuss prices. (3) To collect and distribute information relating to the trade, its requirements, difficulties, and dangers. (4) To examine and report upon inventions and processes affecting the trade, and the supply and quality of the materials used. (5) To deal with labour questions. (6) If desired, and when requested by the parties, to arbitrate on and adjust trade disputes by competent and recognised authority. (7) To grant certificates of competence in the art to individuals." We shall be pleased to receive any expression of opinion from those of our readers who are interested in this matter.

UNIVERSITY COLLEGE, BRISTOL.—We would call attention to the following information which has reached us with respect to the Physical and Chemical courses at this college:—"In the chemical department lectures and classes are given in all branches of theoretical chemistry, and instruction in practical chemistry is given daily in the chemical laboratory. Excursions to some of the mines, manufactories, and chemical works of the neighbourhood are occasionally made. The department of experimental physics includes various courses of lectures arranged progressively, and practical instruction is given in the physical and electrical laboratory. The department of engineering and the constructive professions is designed to afford a thoroughly scientific education to students intending to become engineers, or to enter any of the allied professions, and to supplement the ordinary professional training by systematic

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technical teaching. This department includes courses specially arranged for students intending to become civil, mechanical, electrical, or mining engineers, surveyors, or architects. Those who attend the mechanical engineering course enter engineering works during the six summer months, and, in accordance with this scheme, various manufacturing engineers in the neighbourhood have consented to receive students of the college into their offices and workshops as articled pupils. The engineering laboratory is provided with a powerful testing machine, and instruction in the use of tools is given in the workshop."

ELECTRICITY V. GAS.—The owners of large private houses in the country are beginning to find out that electric lighting offers immense advantages over private gas works such as was adopted when electric lighting by means of incandescent lamps was unknown. It will be remembered that Mr. O. E. Coope some two years or more ago gave his experience of fitting up the electric light, and compared it with the cost of erection of gas holders, &c. The difference in cost was very small (being about £140 out of £1,400) in favour of gas. The great improvements introduced in dynamo machinery and the reduction in prices which has since been made would, we believe, turn the scale largely in favour of the electric light. In any case, we believe that if owners of houses who are contemplating the erection of gasworks for their own use will send to the leading firms connected with the electric lighting industry they will get estimates for carrying out their work at as low a cost as it could be done by means of gas, with great additional comfort to themselves. In addition to this, the steam engine employed for driving the dynamo machinery could be utilised for many purposes during the day, such as pumping, &c. We should like to see some competitive tenders:—1st, For supplying a complete installation for a house, say, requiring 300 lights, including engines, dynamo, fittings, &c., complete by electric light. 2nd, Gas holder, furnaces, gas pipes, fittings, &c. This data would, we feel sure, be very useful to many. Perhaps some of our readers will supply us with copies of estimates they have received for the supply of gas plant, also what estimates they have given in competition for electric lighting.

THE ELECTRIC LIGHT AT THE BIRMINGHAM ART GALLERY.—We made some reference to this installation in our last issue, but the following extract from a local paper will be read with interest :—The *Birmingham Daily Post* says :—" The new electric lighting of the Art Gallery the Rotunda, has now had upwards of a week's trial, and, with some slight modifications upon the original arrangement, is found to give the fullest satisfaction. The heat from the gas-lighting on a damp day, and when a public gallery is full of people, has a most injurious effect on pictures, and Mr. Whitworth Wallis has been refused the loan of some desirable pictures on this account alone. In addition, however, to the heat, the products of combustion, principally of an acid character, have an even more injurious influence, and whatever devices the gas engineers have arrived at for confining and carrying these away, it is impossible to persuade the owners of valuable pictures that any system of gas-lighting will make them safe. The incandescent lamps are arranged in a circular frame attached to the structure of the central gas pendant; but a new departure is in the introduction of silvered-glass reflectors, constructed so as to throw the principal portion of the light upon the surrounding walls, while, at the same time, sufficiently illuminating the floor. An additional and important circumstance in connection with these reflectors is the economy effected, the pictures being better lighted by their employment than if double the number of lamps were employed. This means a saving on account of capital and cost of maintenance of about £500 original outlay and £100 per annum. The mirror arrangement is entirely new, and the results are such as were not expected by experts in the matter. There is no doubt that the principle will hereafter have a large field for its employment in the lighting of shops, club rooms, and large apartments generally. Mirrors of this kind can of course only be used with electric lamps, as gas smoke would at once dim the reflecting surface. The entire installation consists of a nine horse-power nominal Otto gas engine, of the latest type, and with special arrangements to secure steadiness, a result which is very perfectly attained. This drives a ten-unit Chamberlain and Hookham patent dynamo, specially designed for this installation. With its actual load it has an electrical efficiency of 95 per cent., the armature coils absorbing only 2 per cent. It is absolutely sparkless, and having an automatic brush arrangement, requires little attention. The leads are very heavy, absorbing only 2 per cent of the current which they convey from the dynamo to the lamps."

ELECTRIC LIGHTING IN ITALY.—An Italian correspondent of *Industries* says :—" Many of the smaller towns of Italy are about to follow the example set them by Milan in the matter of electric lighting. The success of the Edison Company in Milan has been so great that the municipal authorities are encouraged to become themselves undertakers for the electric light, and are inviting tenders for the supply of apparatus and material. One example is furnished by the town of Udine, which is about to provide itself with 5,000 glow lamps for house and street lighting. The motive power in this case is obtained from three waterfalls, the most distant of these being situated three miles away from the town, and the nearest 1¾ miles. At each of these three stations alternating current dynamos will be driven by turbines, but the exciting current for all these machines will be supplied by a continous current dynamo placed at the last-named station. The alternating current delivered by these machines will be used to work transformers, placed at convenient points. The peculiar configuration of the town, and the unequal distribution of the lighting, requires the use of a rather large number of transformers. Each of these sub-stations is surrounded by an Edison net work, which distributes the secondary currents to the lamps. The total loss of energy allowed in the main lines between the machines and the transformers is estimated at 20 per cent. This high figure has been chosen in order to save copper in the conductor. The loss in the secondary mains will be limited to 4 per cent. of the potential at the terminals of the secondary coils of the transformers. It is expected that the installation at Rome will be ready for work before the end of September. The peculiarity of this installation is that it has been undertaken by the gas company of Rome. Here also alternating currents and transformers are employed. The electric light in Turin is not in so good a position. It has been divided between two systems, and up to the present not much progress has been made with either of the installations. One of these is an Edison plant, which has given much trouble during the last few months on account of the careless way in which the underground conductors have been laid down. The cables were at first placed in soft and yielding soil without any mechanical protection. After this, naked overhead wires were tried, but great difficulties were again experienced with the insulation. The other system is that of alternating currents, and, curiously enough, this has again been divided. Gaulard and Gibbs are providing for the street lights, while the house and shop lighting is done by the Zipernowski-Déri Company. The small seaside town of San Remo will also be shortly supplied with electric light."

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A PORTABLE ELECTRIC LAMP.*

BY W. H. PREECE, F.R.S.

The demand for a new safety lamp in mines has directed many minds to the application of electricity to this purpose. Some have proposed to use primary batteries; others utilise secondary batteries or accumulators. One of the most portable, compact, and convenient forms is that of Mr. Pitkin. It occupies a cubical space of 59 cubic inches for two cells, and 86½ cubic inches for three cells, weighing 5lb. 8oz. and 7lb. 3oz. respectively. The three-cell battery gives a light equal to 2·5 candles immediately after removal from the charging source, and lasts for nine or ten hours. I have also used it for other purposes. It is a most convenient portable lamp for going into a wine cellar or visiting our greenhouses, and it makes a very convenient reading lamp for railway travelling. I carry such a battery in my dressing bag, and by means of a flexible cord carrying two copper conductors I suspend by a hook to my waistcoat front a small candle-power Edison-Swan lamp that concentrates upon my book or my paper all the light I want. The lamp is fixed in the focus of a reflector whose surface is enamelled dead white, instead of being bright polished. The light is thus much more equably and uniformly distributed. It is, moreover, soft, absolutely steady, and free from smell or annoyance to my fellow passengers. It is lighted instantly without any match, and it can be rapidly replaced by a small coil of fine platinum wire, which, being raised to incandescence, enables me to light my cigarette.

IMPROVEMENTS IN ELECTRIC SAFETY LAMPS.*

BY J. WILSON SWAN, M.A.

I showed an electric safety lamp in this section last year. I have now improved the lamp in various ways, and I propose to describe and exhibit the improvements. The objects I had in view in altering the original design were :—

1st. To reduce the weight as much as possible, consistently with the giving of sufficient light.

2nd. To simplify the construction, with a view to minimising the cost of manufacture, and the cost of keeping in order.

3rd. To make the lamp better able to resist a blow.

4th. To seal in the liquid, so that the lamp could be held in any position.

5th. To add a fire-damp indicator.

The lamps on the table embody these improvements, and are here for the inspection of members. The details of construction and the record of experiments are given in the diagram. With regard to the first point—namely, the size and weight of the apparatus—that, of course, depends in a great degree, on the amount and duration of the light. Guided by the fact that the best of the oil safety lamps scarcely gives the light of one standard candle, and that most of those in common use give only a quarter or half a candle, I have assumed that an average light of one candle, over twelve hours for datal men, and 1¼ candle over nine hours for hewers, is sufficient, and I have fixed the size of the battery in the new lamps on this assumption. No alteration of the design is necessary when more or less light than this is required, but merely an increase or decrease of the size and weight of the battery contained within the lamp body.

In this respect the electric safety lamp has a marked advantage over all safety lamps of the ordinary kind which depend on the combustion of oil; *they* cannot be made to give a much larger light without radical alteration, if at all. If the electric safety lamp is required to give five or even 10 candle-light, it is only necessary to proportionally increase the size and weight of the battery. Safety is not in the slightest degree impaired. There is nothing easier than to be deceived as to the amount of light that can be obtained from a certain size and kind of battery applied to an incandescent lamp. If the lamp is constructed so as to allow such a large current to pass through the carbon filament as will heat it to the enormously high temperature at which disintegration rapidly takes place, ten times as much light is produced as when, by the use of a different lamp, the current is diminished, and the temperature of the filament thereby lowered to a degree which will prolong the life of the lamp to an economical point.

In the case of a miner's safety lamp, it is very desirable to get as much light as possible from a given weight of battery, and hence it is allowable to subject the lamp filament to what may be termed a rather high pressure, but not such a high pressure as will prevent the lamp from lasting about 700 hours. Subject to this condition I find I can obtain an average light of one standard candle during twelve hours, and 1¼ candle during nine hours from a battery which, with all the appurtenances of the lamp attached to it, weighs altogether 6¼lbs. The same battery, with a different lamp filament, will, of course, give either more light for a shorter time, or less light for a longer time than that I have mentioned. The battery cells are slightly different in construction from those in last year's lamp. They consist,

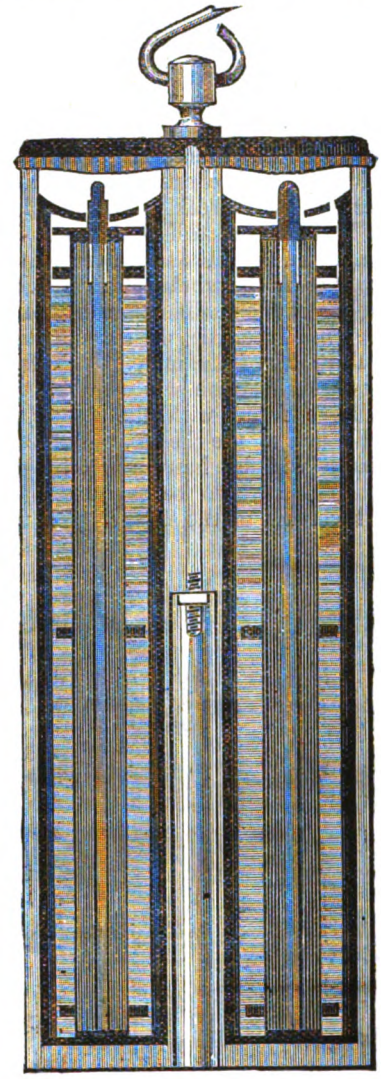

FIG. 1.—Sectional Elevation.

as before, of a central solid cylinder of peroxide of lead, with a conducting core of lead wire, fixed concentrically, by means of guide rings of india rubber, within a tube of lead, the internal surface of which is in the spongy state. The annular space between the peroxide of lead cylinder and the lead tube is filled with dilute sulphuric acid. Four such elements are fitted into four ebonite lined holes in a block of wood saturated with paraffin. The lead wire connections between cell and cell are covered with india rubber, and embedded in channels in the wood, and covered with Chatterton's compound. Over the buried connecting wires is fixed a veneer of ebonite, which further protects them, and also forms a level seat for the cushion of india rubber, which, when pressed down by the cover-disc, makes the cells liquid-tight, so that the whole block may be laid on its side, or inverted, without leakage.

* Paper read before the British Association at Birmingham.

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In the form of lamp I showed last year, the cover of the case which contained the battery had to be screwed off to get at the battery terminals, for the purpose of putting them in connection with the charging circuit. In the new design, the removal of the cover is avoided by bringing down the battery terminals to the bottom. Access is given to these through two small holes, within which fit two pins connected with the positive and negative charging wires. Charging is effected by simply placing the lamp on a bench fitted with charging pins, in connection with wires from a dynamo, so that the charging pins enter the two holes at the bottom of the lamp case. The lamps remain on the dynamo circuit, receiving their charge during the time the men who have used the lamps are resting, and they become fully charged by the time these men return to work.

It is a point in favour of this kind of lamp that the operation of renewing the charge is effected with little trouble and cost—far less than is involved in replenishing and cleaning ordinary safety lamps. For example, one horse-power is sufficient to charge one hundred lamps at a time; that item of cost will, therefore, not exceed a farthing a lamp per week.

The total cost will not exceed fivepence per week, where several hundred lamps are in constant use. That amount will, I estimate, cover the total weekly cost per lamp, including renewal of lamp-bulbs, the cost of fuel, wages for keeping the lamp charged and in repair, and interest at 10 per cent. on the capital outlay for the whole plant including the lamps themselves. In one of the modifications of the lamp the light is fixed upon the top of the case, with a view to the illumination of the roof and sides of the mine. This form of lamp is intended for the use of overmen while travelling in the workings. The bullseye form, with the light on one side, is intended for the use of the hewer. While the hewer is at work the lamp will be hung up on a hook as usual. Where low workings have to be traversed the lamps can be fastened to the breast of the miner by a strap across the shoulder.

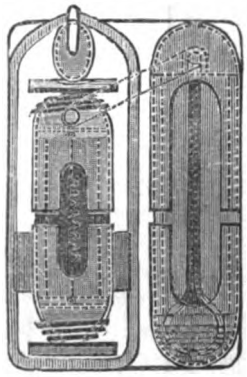


FIG. 2.—Fire Damp Indicator.

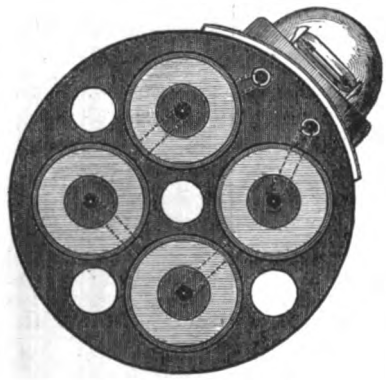
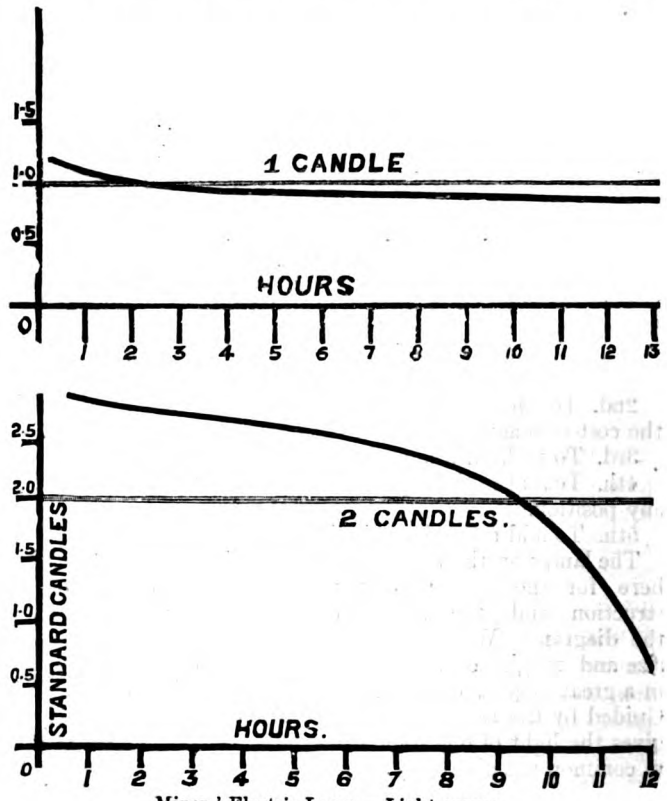


FIG. 3.—Sectional Plan.

The only other point requiring explanation is the fire-damp indicator. The want in the lamp I showed last year, of the means of showing the presence of fire-damp, was urged as an objection to it. I have met the objection by adding an indicator. This will not be required on every lamp, but only on lamps used by overmen. I have made the indicator in three forms; two of these act on the same principle as Liveing's fire-damp indicator. A spiral coil of thin platinum wire is arranged so that it can be heated to a low red heat by switching through it the current generated by the lamp battery. If this takes place in an atmosphere in which fire-damp is present, the wire becomes hotter than when heated in pure atmospheric air, because combustion of the fire-damp with the oxygen of the air, brought about by the electrically heated wire, produces additional heat, and, consequently increases the temperature of the wire, so that it is sensibly brighter when heated in air containing fire-damp than when heated in air in which there is no fire-damp.

In one form of the indicator I have followed Mr. Liveing's idea of having a comparison wire, shut up, air-tight, in a glass tube containing pure air. In another, I have deviated from Liveing's construction in two ways, namely, by having only one wire (the test wire), and instead of this being in a wire gauze cage, always exposed to the atmosphere in which the lamp is placed, it is in a tube which, when the current is turned on to heat the wire, is completely closed. It is not easily conceivable, even if the test were made in an atmosphere of air and fire damp of maximum explosiveness, that flame would pass the four-fold lining of fine copper wire gauze of the Liveing indicator; still it is, perhaps, more consistent with the absolute safety of the lamp itself, to make the test in a closed vessel. With the double wire arrangement, when fire-damp is present in the air, even in so small a proportion as a half per cent., the *exposed* wire glows with perceptably greater brightness than the *enclosed* comparison wire. With the single wire arrangement, under the same atmospheric conditions, the wire would glow for an instant with extra brightness, and then, after the small quantity of enclosed fire-damp is consumed, would die down to normal redness.

The third form of indicator acts upon a different principle. In it there is a platinum wire within a small tube, and the means of turning on the current from the lamp battery to heat the wire, as before; but here the hot wire is employed only to



Miners' Electric Lamp.—Light curves.

effect the combustion of any fire-damp that may be present, with a view to the production of a partial vacuum resulting from the condensation of the watery vapour of the burnt gases. The degree of vacuum or shrinkage is shown by the rise of liquid in an adjacent gauge tube, and from this the exact per centage of fire-damp present in the air may be ascertained. This form of test is also, and necessarily, made in a closed vessel. The hot wire is completely cut off from contact with the outer air.

I think it will appear to the section that I have produced a miner's lamp having the advantage of absolute safety, and which is at once more efficient and more economical than any other miner's lamp yet constructed.

DISCUSSION.

Mr. SWAN, in answer to a question put by the Chairman as to what would happen in case the glass of the lamp should break, said that he had not had an accident of the kind, and it was not easy to conceive of such a contingency, because the glass was exceedingly thick—so much so, in fact, that if a lump of coal were to fall upon the glass the coal itself would break, and not the glass, which was about an eighth of an inch thick. But if for a moment it were supposed that the lamp was struck

with a hammer, so as to break the glass, the small lamp, which was held between two springs, would be knocked out of its place, and its electrical connections would be detached.

Prof. FORBES said that he had been very interested in the paper contributed by Mr. Swan, because it happened that he (the speaker) had occasion during a great number of years to try, in conjunction with others, to do as much as possible for procuring safety in the working of coal mines. The first thing that occurred to everyone in connection with such a lamp as that which Mr. Swan had exhibited was, what would happen if the lamp broke? The question had already been asked, and Mr. Swan had, to some extent, answered it. But Mr. Swan had not told them specifically if the lamp were broken in air containing an explosive mixture whether or not an explosion would take place. That might, perhaps, be beside the question, because Mr. Swan might say that such a thing would never happen, but he would like to know whether, if such a lamp were broken in an explosive mixture of fire damp, an explosion would take place. He did not know whether Mr. Swan in person had ever tested the lamp under such conditions, but if he had, considerable confidence might have been placed in his invention. That part in the paper which related to the detection of the presence of fire-damp and the measurement of it was exceedingly interesting and important. The miner's objection to an electric lamp of any kind was always what Mr. Swan had pointed out, namely, that it had not got the means of detecting fire-damp. An ordinary miner's lamp, when taken into a coal mine where the dangerous explosive might exist, showed by a blue tinge about the flame the presence of the fire-damp if it exceeded one per cent, and allowed him to approximate roughly the quantity of fire-damp which was present, so that one could determine whether it was large or small. That was the only apparatus used at present in coal mines for determining whether there was fire-damp in them or not. A great many years ago it seemed to him (Prof. Forbes), or rather it was urged upon him by people who had coal mines under their charge, that it was very important to introduce some independent and more scientific method of detecting fire-damp in mines. A device occurred to him which seemed to be very promising, and that was to determine the density of the gas by means of the velocity of sound through it, or by means of the sound of a resonator containing the air of the mine which would respond or resound to a tuning-fork of a definite pitch. He made a practical instrument with that object, which he believed was still in use in two collieries in Lanarkshire, but which was discarded by most of the miners because they liked their old safety lamp much better. Last year he met a gentleman, Mr. Blakeley, who had made numerous experiments on the velocity of sound, and who was associated with him (the speaker) in improving the apparatus, and they did improve it and made it practically perfect. But the same objection applied to it in that it did not overcome the conservative tendencies of the miners. Mr. Liveing had introduced a system which Mr. Swan had adopted in some of the indicators which had been shown, namely, to have two wires, which might be of platinum, and to heat them by the passage of an electric current through them, and to have one of the wires in pure air, and the other in the air of the mine. If the air of the mine contained a hydro-carbon gas—the fire-damp—the extra brilliancy of it was at once detected. The indicator was very sensitive. Mr. Liveing had put into it a photometric arrangement for enabling him to compare with accuracy the intensity of the brightness of the two platinum wires, and by that means was able to measure distinctly one-half per cent. of fire-damp mixed with the air. With Mr. Swan's arrangement the percentage required, as he imagined, would be rather greater in order to render the presence of the gas evident. He fancied that the arrangement which Mr. Swan had exhibited where there was only one wire—that exposed to the air of the mine—must be sensible to only 1½ or 2 per cent. He would like to hear Mr. Swan's opinion about the sensibility of the single wire in estimating the quantity of fire-damp in a mine. Mr. Swan had shown them another apparatus which struck him as being new in form and more scientific even than the other. It was devised for quantitatively estimating the hydro-carbon present, and seemed to be a very admirable system indeed. It reminded him of a system of the kind in use in some of the Belgian mines. It was the invention of M. Somzee, and was exhibited in the Paris Exhibition of 1881. It was the most remarkable fire-damp indicating apparatus he had ever seen. It was founded on the same principle of detecting the fire-damp, and measuring the quantity present by the rise of the mercurial tube. The apparatus was placed at the bottom of the mine, and periodically—every quarter of an hour—it took into its reservoir or receiver a supply of the air of the mine. It then analysed it by the same method, the most scientific method of analysis employed in the chemical laboratory. Having performed these functions automatically, it telegraphed the result to the mouth of the pit, and prepared itself to repeat the operation a quarter of an hour later. The same principle was adopted in Mr. Swan's latest invention. He heartily congratulated that gentleman on the advance he had made in this important direction, and on producing a lamp for miners which was necessary for their safety. But he could assure the inventor that miners, who were a most conservative class of men, would not adopt it if it was not to their own taste.

Mr. A. SOPWITH desired to know whether the lamp could be held in any position, as, for example, where the light was placed at the side of the lamp could it be used for examining the roof of the workings in a coal pit? If Mr. Swan could give them the assurance that the lamp could be put into the hands of the miners and they could turn the lamp so as to direct the light on the roof of the workings (and he considered that was one of the great defects of the ordinary miner's lamp), a great advantage would be gained by the invention.

Mr. SWAN replied that he could give that assurance. As a matter of fact, the lamp he now held in his hand had been more than once in a coal mine, and carried for very considerable distances in that position [holding the lamp horizontally], and, in fact, had been moved about in every position. He thought it was an exception to the general rule, but where every man at work was required to examine for gas in the roof of the mine he thought that the operation could be performed perfectly well without altering the form of the lamp. There would be no difficulty at all in using the lamp with the light on the side for examining the roof and ascertaining whether or not there was fire damp present.

In answer to Mr. JOSEPH STURGE, Birmingham, who asked whether the lamp exhibited fulfilled the conditions imposed upon the competitors for the prize offered by Mr. Ellis Lever for a safety lamp two years ago, Prof. SILVANUS THOMPSON explained the circumstances under which the committee appointed to adjudicate on the lamps on that occasion met at Woolwich week after week, and went on to say that they had in the course of their labours examined somewhere about eighty different kinds of lamps. A large number of those sent in were rejected at first sight because they obviously did not fulfil the conditions of the competition. For example, one lamp weighed about 1cwt., and another sent out a narrow beam of light very much like a magic lantern. In fact, a great many of the lamps, however meritorious they were in some respects, had to be rejected because they failed to fulfil one or other of the requirements. The beautiful little lamp sent by Mr. Swan on that occasion, and which was not a self-contained lamp, was not to be compared with that which had just been shown to the section. If some other benefactor would come forward and offer another prize of £500 or more for a perfect safety lamp, which would be portable, self-contained, and give a light of at least one candle for twelve hours, he fancied there would be a still more numerous array of lamps entered for the competition. But until then he must say that, as far as he knew at the present moment, the lamp now exhibited by Mr. Swan was the very best that existed.

Prof. SMITH said he was extremely interested when he saw the lamp shown by Mr. Swan at Aberdeen last year, and he ventured to express the hope on that occasion that Mr. Swan would be able to add to it an indicator. That hope seemed to be now realised in two distinct and very beautiful ways. Both Mr. Swan, and the mining community especially, were to be congratulated on the decided advance which had been made. One point which had not been noticed much by the section was worthy of attention. At Aberdeen last year the lamp exhibited weighed 6¾lb. As they had just been told the weight had been reduced to 5½lb. This might seem to some a small diminution; but when one came near the limit of possibilities even that small diminution represented great efforts, and it was one of the qualities of superiority in the lamp shown over that exhibited by Mr. Swan last year. Mr. Swan had partly explained what would happen if the glass of the lamp were broken, but he would like to ask one question in that connection, namely, whether the spark that must exist at the time of atmospheric contact would lead to any danger?

Mr. DESMOND FITZGERALD wished to draw the attention of the section to the fact that all secondary batteries, and particularly those batteries adapted for the production of small lights, might be greatly improved by the use of what was practically a new invention called lithanode. Drawing their attention to the diagrams exhibited, he desired to point out that the red lines represented peroxide of lead, the most highly electro-negative substance with which chemists were acquainted, and the blue line represented lead which was an extremely electro-positive body. He need not point out that those substances were in contact with each other, and also with the electrolyte in the cell. Those were the essential conditions of the production of a voltaic circuit which in the present instance was local. Electricity passed from the lead to the fluid, from the fluid to the peroxide, and from the peroxide back again to the lead. The result was extremely detrimental to the working of batteries, as was generally understood. It was detrimental in several ways. In the first place there was a continual loss of energy by this local action, and in the second place the element as represented would be gradually destroyed. The great objection in this case was the addition to the weight of the apparatus consequent upon the use of metallic lead, which he had already said was so detrimental. The question had long been asked, how was it possible to dispense with that metal? He ventured to express the hope that the question had been completely and satisfactorily answered by the introduction of a material which he termed lithanode. It was a peroxide of lead of high conductivity. It was comparable in that respect to carbon, and it constituted, he thought, the most perfect element for secondary batteries, and especially for batteries for small lights. He most heartily congratulated Mr Swan on the success of his endeavours to mitigate the awful sacrifice of life consequent upon the obtaining of coal, and the world owed him a debt of gratitude for his labours. Mr. Swan might, however, still further improve his lamp by greatly reducing its weight by the use of lithanode as a negative element. He must observe that as it stood Mr. Swan's battery was, comparatively speaking, a heavy one. The figures he had taken note of were 5½lb. as the weight, the current being ·14 ampere.

Mr. SWAN: I spoke of the current in amperes as being about ·4.

Mr. FITZGERALD, who was asked by the chairman to abbreviate his remarks as much as possible, said he would in that case content himself with pointing out that a horse-power was now obtainable very considerably within the weight of 100lb. His remarks might be summed up by saying that by using the improved conductor, and dispensing with the lead, the weight of the battery could be greatly reduced, or the illuminating power increased, or the number of hours during which the battery could be used would be increased.

Mr. SWAN, in reply, said that if Mr. FitzGerald had discovered any means of reducing the weight of a battery the discovery would be very welcome indeed. Mr. FitzGerald had called attention particularly to the weight involved by using a combination of metallic lead and peroxide of lead in the ordinary construction of anodes in secondary

batteries. No doubt there was a great deal of unnecessary lead used, and in the construction of his battery he had paid particular regard to that very point, with a view to the diminishing of the weight. He had got as little metallic lead as he possibly could make it with. He had also kept in view the point that Mr. FitzGerald had raised as to the undesirableness of the loss by local action. He had so designed the battery as to reduce the local action between the metallic lead which formed the core of the anode to the very smallest possible limits, and being in the centre it was removed very considerably out of the sphere of electrolytic action. From an examination of some cores after being a considerable time in use, he thought it was probable that there was no electrolytic action going on at all between the lead wire which formed the core of his anode, and the ingredients which formed the actual material of it.

The PRESIDENT (Sir James Douglass) said that they must all feel indebted to Mr. Swan for his very valuable paper. They could as yet scarcely realise its importance. They might not all remember, but they must all know historically, what an intense sensation was caused when Davy produced his first lamp for the use of miners. The lamp was, of course, a great improvement on the old one. But they all knew that miners had had to work with a very imperfect lamp. Everyone who had any knowledge of the subject knew how imperfect the instrument was. They could not, therefore, attach too much importance to the invention of Mr. Swan. There was every probability that they would now have a perfect instrument, and if it was a perfect instrument there was no doubt it was due to Mr. Swan. Whoever might follow it up with improvements, Mr. Swan had really produced the lamp. He concluded by moving a hearty vote of thanks to Mr. Swan and Mr. Preece for their valuable papers.

LITHANODE.*

BY DESMOND G. FITZ-GERALD.

The object of the present paper is to draw attention, as briefly as possible, to a substance for which it is claimed that it constitutes the negative element, *par excellence*, for voltaic batteries, primary or secondary, and also a perfect anode for the electrolytic separation of the most electro-negative elements, *e.g.*, chlorine.

It may be as well at once to specify the main desiderata in a negative voltaic element, and also the essential conditions in an anode applicable generally and commercially in electrolysis.

A negative voltaic element should be not only strongly electro-negative (inoxidisable) in itself, but also capable of retaining its electro-negative condition when constituting a cathode traversed by a (comparatively) strong current for a (comparatively) long period of time.

The electro-negative material of which it is constituted should not be associated with any relatively electro-positive substance, in contact with it and with the electrolyte; or, in other words, local voltaic action should be impossible. It should not be liable to disintegration or corrosion.

From an economic point of view it is essential, in order to render practicable the use of the element on an extended scale, that the abstract cost of the energy developed by means of the voltaic combination of which a given negative element forms part should not exceed one halfpenny per horse-power hour. It is most desirable, and it is also quite within the limits of practicability, that this cost should not exceed half this value. In other words, it is most desirable that we should be able to show in any given locality, that we can restore to a given battery, constructed with the given negative, the energy corresponding to an expenditure of 736 watts during one hour by means of the combustion of one farthing's worth of coal. From another economic point of view it is desirable in certain applications that the ratio of battery work to weight of negative element (inclusive of depolarising substances) necessary to develop this work should be relatively high. Lastly, an efficient negative voltaic element must possess a degree of conductivity such as will admit of a very low ratio between the quantity of energy converted into heat by the passage of electricity through its substance, and the quantity of energy converted into heat by the passage of electricity through the electrolyte under the best conditions obtainable.

Excepting the substance now presented to your notice, there is no negative voltaic element in which all these desiderata are fulfilled.

The essential conditions in an anode applicable generally for electrolytic decompositions on a large scale are that it must be chemically unattackable both by oxygen and by chlorine in the nascent state; it must not disintegrate by the action of the gases evolved from its surface; surfaces of any required area must be obtainable without any liability to augmented resistance and consequent sparking and heating at joints in the material; it must possess sufficient hardness to resist abrasion by contact with ores, &c.; and its cost must be small. The applications for an anode fulfilling all these requirements are practically unlimited; but with the exception of the substance I now bring before you, there is no material possessed of all these desiderata.

This substance termed lithanode, which for some time past has been known to a few electricians in this country and in France, is peroxide of lead in a dense, coherent, and highly conductive form, obtained, without any admixture of inert cementing or agglutinating material, and free from any contact with lead or other oxidisable body, by a process of which the original and essential features are described in my patent specification of April 15, 1885. But before adverting to the principle involved in its manufacture, it will be interesting to glance at the *raison d'être* of lithanode and to its position in the series of inventions by which the storage battery of the near future has gradually been evolved. Planté obtained peroxide of lead—almost identical in chemical composition with lithanode—in the form of very thin layers in contact with metallic lead.

The objections to Planté's negative were due to the difficulty of sensibly augumenting the thickness of the layer of peroxide initially obtained, and also to the local action between this layer of oxidant and the metallic lead beneath it. The former of these objections was overcome by Faure, whose inventions rendered it possible to obtain layers of active material of any required thickness. The objections to Faure's negative were threefold: first, the necessity for the use of parchment paper or felt to maintain the layer of active material in position; secondly, the liability to defective contact between this layer and its supporting lead plate; and, thirdly, the local action between the peroxide and the metal, limited, it is true, by the circumstance on which the preceding objection is based, but resulting, nevertheless, in a continuous waste of energy and in the ultimate destruction of the supporting plate. The first of these objections, and, to a great extent, the second also, have been obviated in the Faure Sellon-Volckmar accumulators manufactured by the Electrical Power Storage Company; but the third objection is still applicable to the negative element in this otherwise greatly-perfected form of secondary battery.

Obviously the next step in the process of development was to realise the condition I have referred to, under which local action is entirely precluded. This step almost necessarily involved a complete alteration in the form of the negative element, and a coherent plate of active material, independent of any surface support, afforded the most perfect solution of the problem; although in certain cases a support of non-conducting material might be useful. The question was, how to obtain a dense coherent plate of peroxide of lead without the use of any cementing or agglutinating substance of which the effect would be to augment fatally the resistance of the electrode? This question has received a practical solution only after many failures, some of which bore at first the appearance of success.

If we mix oxide of lead with water, and mould the plastic mass thus obtained into the form of a plate, this, as might be expected, will be very friable when dry; and, when immersed in a fluid, will resolve itself into the original pasty form. In order to obtain a coherent solid, without the use of an inert cementing body, it is necessary to produce a molecular change in the plastic mixture, so as to cause it to "set." Such a molecular change may most readily be brought about by a partial chemical change occurring in the moulded mass, provided such change be not too rapidly effected. If, for instance, we blend a certain proportion of finely-divided metallic lead with the oxide of lead and water, the re-arrangement of molecules due to the gradual oxidation of the lead in presence of air will have the effect of greatly increasing the cohesion of the mass so as to allow of its immersion in a fluid without disintegration. The resulting plate, when electrolytically peroxidised, will possess a considerable degree of cohesion and hardness constituting the product known to some electricians under the somewhat barbarous term of *petranode*. Better still—

* Paper read before the British Association at Birmingham.

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and this is the invention to which I would draw your attention —if we mix our oxide of lead with a solution of a salt which will gradually be decomposed by the oxide—as, for instance, ammonic sulphate, from which ammonia is evolved whilst a certain proportion of the lead oxide is converted into plumbic sulphate—we may obtain a dense and coherent mass which, when electrolytically converted into peroxide of lead, constitutes *lithanode*.

From what has been said, it will be seen that this substance is in chemical composition almost, if not quite, identical with the active material in the anodes of the various forms of secondary battery which have been proposed for use on a large scale. The difference is one of molecular constitution, allowing of the use of an anode wholly composed of peroxide of lead, and consequently entirely free from the liability to local action. Moreover, the anode in question—unlike those which may be constructed with chemically-produced peroxide of lead—possesses in sufficient degree the quality of conductivity, and will withstand without deterioration and for an indefinite period the effects even of very rapid charge and discharge. When used in voltaic batteries, either primary or secondary, it offers a threefold advantage: first, it gives us a permanent element in lieu of one which contains the elements of its own destruction; secondly, it economises the energy elsewhere expended in local action; and, thirdly, it enables us to reduce the weight of the apparatus. The importance of this result does not need to be insisted upon in addressing electricians and electro-chemists. For the first time, we have it now in our power to construct an anode which with absolute impunity will withstand the test of a perfect voltaic negative—the electrolytic evolution of chlorine.

I have to apologise for the very imperfect manner in which I have been able to bring this material to your notice. Important improvements in its manufacture are in course of development; and I am unable, therefore, at the present moment to give more than a somewhat abstract view of the latest step that has been made in perfecting the secondary battery, and also the means for carrying out various processes of electrolysis on a commercial scale.

At the close of his paper, Mr. FitzGerald exhibited an experiment which, he observed, was not *primâ facie* of a very scientific character; but which, nevertheless, implied a great deal in favour of the lithanode element. A couple constituted by a strip of zinc, and between two and three square inches of platinum foil, immersed in dilute sulphuric acid, was circuited through an electric bell without producing any effect. The platinum was then replaced by a narrow strip of lithanode, which was slowly lowered until it came into contact with the electrolyte—a gentleman present being requested to clap his hands the moment the lithanode touched the acid. It was pointed out that the sound of the bell commencing to ring and the clapping of the hands were simultaneous.

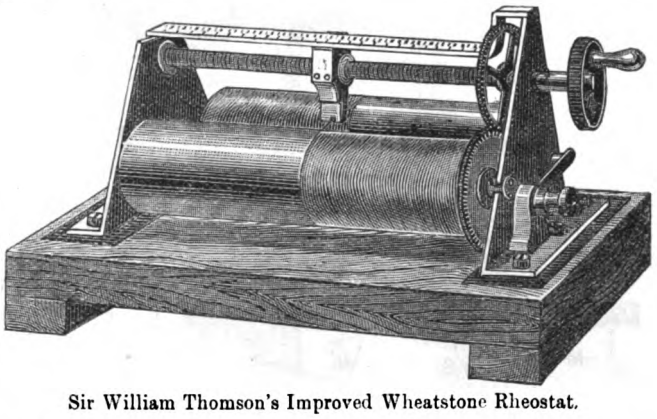
SIR WILLIAM THOMSON'S IMPROVED WHEATSTONE'S RHEOSTAT.*

Wheatstone's rheostat was invented over forty years ago; but, though admirable in conception, and commonly shown on the lecture table in illustrating and explaining the nature of electric resistance, it is scarcely, if at all, used in the laboratory. This is altogether owing to practical defects in the instruments as commonly constructed. The wire becomes loose, the contacts are uncertain, and, the current being incessantly broken and made again, the galvanometer needle is perpetually swinging about instead of showing a continuously increasing or diminishing deflection as the resistance is wound out of the circuit or wound into it.

Modifications of the original instrument have been made from time to time, and a very important improvement was recently introduced by Mr. Joulin, of Bristol. In Joulin's rheostat a toothed wheel fixed on one of the two cylinders gears into a toothed wheel on a shaft carrying the other cylinder, and a spring fixed to this shaft acts on the last-named cylinder, which surrounds it on the principle of the mainspring of a watch. By this arrangement the wire is kept tightly stretched, and the barrels can be turned both forwards and backwards by means of a handle attached to one of them, and the necessity of shifting the handle from one to the other when the motion is to be reversed is obviated.

In Sir William Thomson's improved rheostat the spiral groove in the non-conducting cylinder of previous instruments is dispensed with, and the wire is guided between the cylinders so as to be laid on them spirally by means of a travelling nut in a long screw. The screw is turned by the handle, and carries a toothed wheel which gears into two-toothed wheels, one of which turns one of the cylinders, and the other the aerial shaft of the other cylinder containing the watch spring. The guiding nut is also arranged to stop the motion of the screw-shaft at each end of the range, and so prevent the possibility of overwinding. It also carries an index, which moves along a graduated scale, and counts the turns of the wire on the insulating cylinder.

In Joulin's rheostat the two cylinders are geared together, as already described. The two cylinders are geared together directly, and turn in contrary directions, the wire passing from the upper side of one to the under side of the other. In Sir William Thomson's instrument, as is seen in the diagram, the toothed wheels of the two cylinders are turned in the same direction by the wheel on the screw-shaft, and the wire passes horizontally from the top of one cylinder to the top of the other.



Sir William Thomson's Improved Wheatstone Rheostat.

The conducting cylinder and the wire are both of platinoid, a metallic alloy specially suitable for the purpose. It has very high electric resistance, very small temperature variation of resistance, and it remains with its surface almost or altogether untarnished in the air. On account of the last-named property the contact between the wire and the conducting cylinder is as perfect as can be desired; and continuity of action, which was a great difficulty in the old form of the instrument, is absolutely complete.

* Paper read before the British Association at Birmingham.

A MAGNETIC EXPERIMENT.*

BY W. H. PREECE, F.R.S.

My daughter having finished a piece of needle-work, roughly smoothed it down on her lap, and, in doing so, drove a needle into the palm of her right hand, breaking it into several pieces. All these pieces were extracted but one, and this could not be found by probing. It remained in her hand for a fortnight, causing much pain and inconvenience. An examination by Prof. Hughes with his induction balance, though giving faint indications of its presence, failed to localise it. I tried several forms of this apparatus, but failed. I strongly magnetised a very fine needle, and suspended it to a light arm by a small paper stirrup and a single cocoon fibre. The damaged hand strongly deflected it, and by moving the hand about, the needle invariably pointed to one position, which was marked with a spot of ink. A free and deep incision was made in this spot, and the piece of needle—·4in. long—was found and extracted. The needle went through the opponens digiti minimi muscle, and was found deeply embedded under the deep palmae fascia. The operation was performed by Doctors Pocklington and Page, of Wimbledon.

* Paper read before the British Association at Birmingham.

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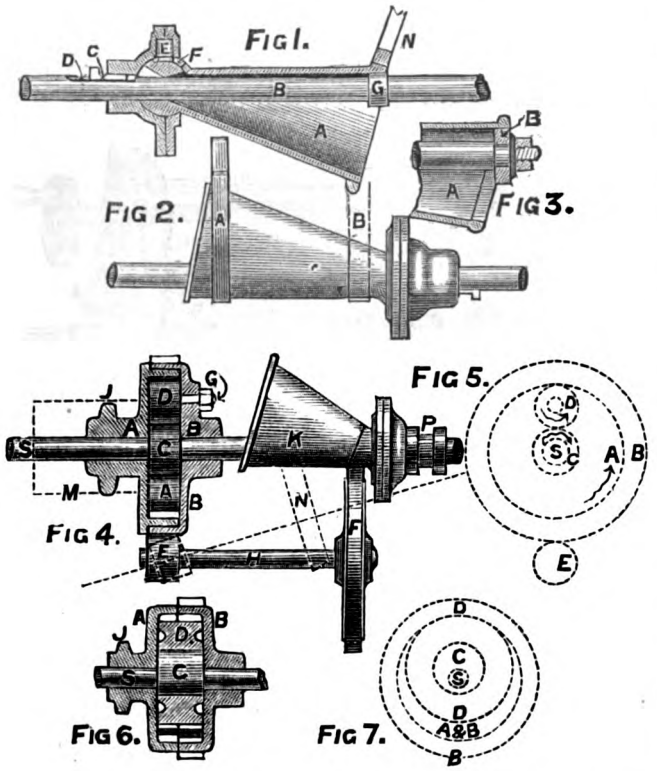
A NEW SYSTEM OF MECHANISM FOR IMPARTING AND RECORDING VARIABLE VELOCITY.*

BY W. WORBY BEAUMONT, M.I.C.E.

Engineers and mechanicians are so well acquainted with the difficulties that have attended the endeavours to obtain mechanism by means of which a determinately variable velocity may be imparted to rotating parts, that it is unnecessary to preface this description of a new system of mechanism by any account of those apparatus which have hitherto been placed before them.

The applications of such mechanism have been chiefly confined to small machinery or to instruments such as speed recorders or integrating machines. This restriction in application is not, however, due to restricted necessity for such mechanism, but to the insufficiency of the devices hitherto made for dealing with large powers.

The apparatus now to be described is, it is thought, applicable for instrumental purposes, or for varying the velocity of rotation of parts of light or heavy machinery.



A leading feature in it is the employment of a hollow cone, mounted concentrically, but ex-axially, upon a spindle with which it revolves, the axis of the cone being inclined from that of the spindle, the direction of the inclination and the plane of the two axes remaining the same while the cone and spindle revolve. This involves a continuous change in the relative positions of any point in the periphery of the cone and of the spindle, or of the distance between any such point and the axis of the spindle.

For this purpose the cone is mounted, so that while it is carried round by and rotates with the spindle, it is free to move in every direction transversely.

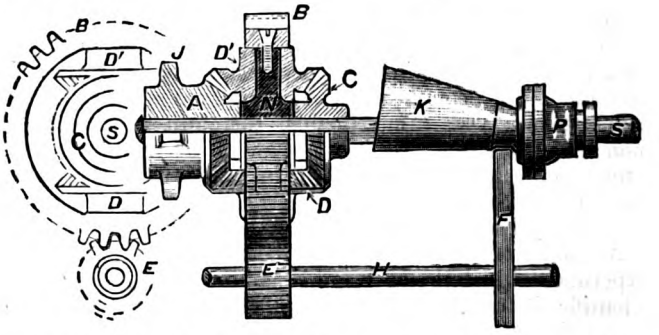
This will be readily seen from diagram Fig. 1, in which A is a section of cone mounted upon a shaft, B, by means of a ball and socket joint, the socket being shown as fixed, but in many cases it would be mounted so as to be capable of longitudinal movement upon the spindle B, and being carried round with it by means of a feather at C, moving in a groove or keyway, D. The cone is carried round by the key E, capable of axial movement, and engaging with the curved slot F, in the ball on the cone.

In the application of these cones for belt driving, the socket would in most cases be fixed upon the shaft, longitudinal movement not being necessary.

Fig. 2, with Fig. 1, shows a pair of such cones, connected by a belt, one cone driving the other, and the velocity of the driven cone depending upon the position of the belt anywhere between A and B, Fig 2. In some practical applications it would be necessary to steady the cone by running the end in a guide or bearing N, Fig. 1, or by guide rollers, but in many cases a roller, as shown at G, would be sufficient. A variable velocity could be communicated, for instance, to a dynamo-electric machine by one of these cones, as shown at Fig. 3, in which A is the cone and B a roller on the end of the spindle.

In the roller and disc devices, and in the known modifications of these for varying velocity and integrating differential velocities, it has been necessary that the area of contact between the roller and disc should be very small, in order that differential velocities in the area of contact should be a minimum, and with the exception of the sphere and roller mechanism of Prof. Hele-Shaw,* this has prevented the adoption in applied mechanics of these types of mechanism for the transmission of any but minute forces.

In the endeavour to overcome this difficulty the author found that the ex-axially mounted cone afforded the means of providing a large area of contact between itself and the periphery of a conical roller or disc, without departing from a purely rolling contact, while for many purposes the differential velocity along the line of contact between the periphery of a short roller or of a disc would not have a materially detrimental effect either in accuracy of result or wear of the surface exposed to rolling and differential rubbing friction.



Variable velocity in recording instruments or in heavy machinery may be imparted by using the cone as a speed-controlling element and not directly for transmission, and of this some illustrations may be given.

In Fig. 4, for instance, any intermediate velocity between the maximum and minimum may be given to the wheel A. The primary shaft is seen at S. Upon this are mounted the cone K, capable of longitudinal movement on the shaft, the externally geared wheel B, the pinion C, and the internally geared wheel A, the last being also provided with teeth at J for conveying motion at the varied velocities, or being in the form of a drum, M, for carrying paper. Gearing with the teeth of the wheel B is the pinion E, which is fixed upon the spindle H of the wheel F, which runs in frictional contact with the cone K. Running upon a stud spindle, G, fixed in the wheel B, is a pinion, D, which gears with the internal teeth of the wheel A and with the pinion C. The wheel F is held by a brake, which is put into or out of gear by the movement of the handle, which changes the position of the cone. As shown in the diagram, the wheel F is not touching the cone. It is fixed when the cone is in the position shown, and therefore the wheel B is held stationary by the pinion E, which is on the same spindle. The action of this gearing will be as follows:—Rotative motion being given to the spindle S and pinion C in the direction of the arrow, Fig. 5, the pinion D will revolve in the opposite direction, and the wheel A will be driven in the same direction as D, the velocity of A being proportional to the relation between the diameters of the pinion C and wheel A. The wheel B, and thereby the spindle of the pinion D,

* Paper read before the British Association at Birmingham.

* *Phil. Trans.*, 1885. Brit. Ass. Reports, 1885.

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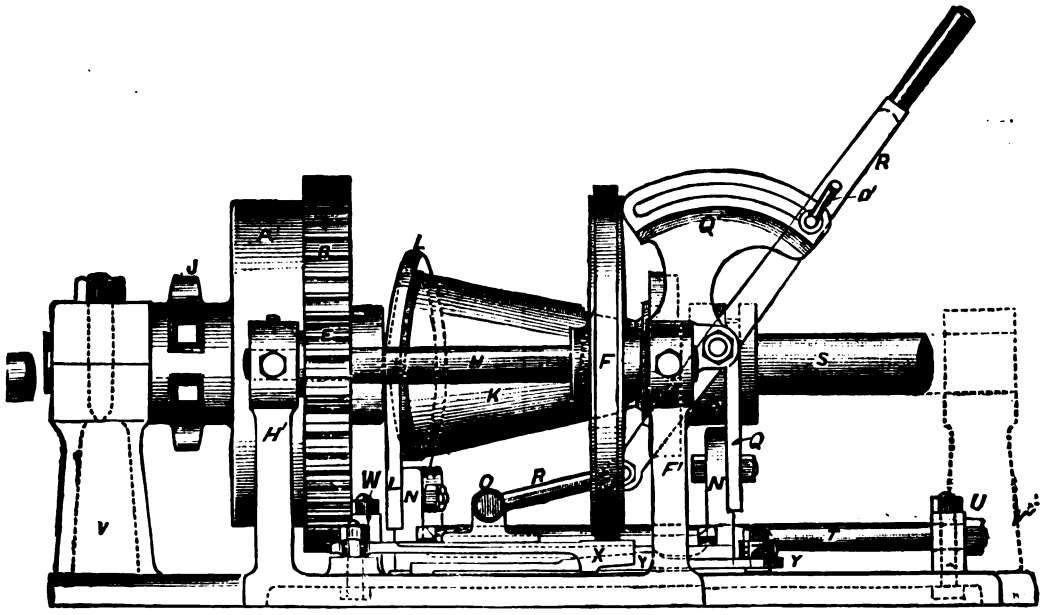
being held fast, the speed of A will be a maximum. Now, if the brake which fixes F be withdrawn and the cone be brought into contact with its periphery, the wheel B will be permitted to rotate in the same direction as C, and at a velocity depending upon the ratio of the diameters of the cones and wheel F, and of the pinion E and wheel B. When the wheel B rotates, the velocity of its rotation is taken from that of A, and the velocity of A will therefore vary in proportion to the larger and smaller diameters of the cone.

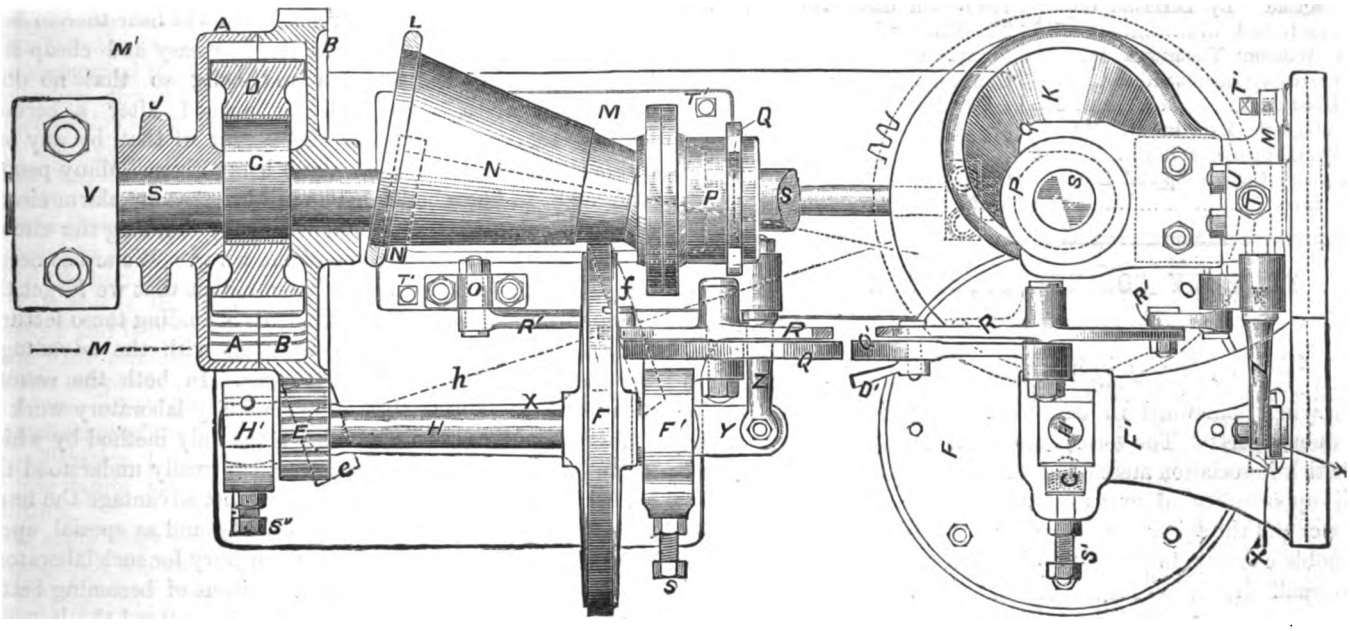
The cone would be moved in the direction of the axis of the spindle upon which it revolves by means of a clutch lever attached to P, and it will be seen that if a pencil be so attached that it moves coincidently with the cone and in contact with paper on M, a curve will be drawn which will vary with the velocity, or lines will be drawn which will show relative velocity.

Instead of using a brake to fix the wheel F, the relative diameters of the wheels and cone may be such that the maximum required velocity of wheel A may be obtained with wheel F in contact with the smallest part of the cone. Inasmuch as the work done on E by the permissive rotation of the wheel B is given up to the cone K by the wheel F there is no loss of work, as there would be if B were permissively rotative by allowing it to slip in a brake.

It will be seen that within the width of the edge of the periphery of the cylindrical disc F there will differential velocity, due to the different diameters of as much of the cone as is included in that width, and the velocity of F will probably be a mean between the maximum and minimum within that width. To avoid the wear and inaccuracy that this would cause in heavy machinery a conical disc, as shown at N, Fig. 4, would be employed.

The possible modifications of this, which may be termed an epicyconoidal mechanism, are almost as numerous as the multifarious applications which are obvious; but it is not necessary here to mention more than the epicycloidal mechanism shown at Figs. 6 and 7, and the bevel or mitre compensating gear used for many purposes.





THE FROST INDICATOR.—In California large numbers of vineyards are fitted with electric bell circuits so arranged as to be closed by a mercury thermometer contact when the temperature falls to zero. By this means the proprietors are warned when their vines are in danger from frost, and many thousands of tons of grapes are annually saved from destruction.

*** We are compelled to leave over to a future issue interesting articles on "Welding by Electricity," "The Central Station at Etienne," &c., &c.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

All communications to be addressed to 1, *Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.*

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THE ELECTRICIAN *can be had, by order, from any newsagent in town or country, at the various railway stations; or it can, if preferred, be supplied direct from the office, on the following terms (paid in advance):—*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

Volume XVI. of "The Electrician" now ready. Price 10s. 6d. Also Cases for Binding. Price 2s.

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FINSBURY COLLEGE SPECIAL LECTURES.

The great scientific gathering of the year draws attention to the fact that the season has so far advanced that holidays will soon give place to renewed labour. Professors and scholars are hurrying homeward to take their respective shares in the arduous work. The former have met in large numbers at the British Association meeting at Birmingham, and thus have had an opportunity of exchanging opinions, discussing the successes and the failures of the year. Birmingham has long set a noble example in the cause of education, and may point with no small degree of pride to such institutions as the Midland Institute and the Mason's Science College. The latter is the more recent foundation, and is almost entirely due to the munificence of the late Sir Josiah Mason. The primary object of the College is the promulgation of scientific knowledge with a special tendency to the applications of science in practice. Foundations with a somewhat similar object are to be found at Newcastle, Leeds, Nottingham, Manchester, Liverpool, Bristol, and in the City and Guilds Institute in London. All these institutions may be properly viewed as the germs of future universities in which the study of languages takes the second and not the first place. No doubt we must trace the development of broader educational views partly to the various Exhibitions held since 1851, partly to the increased facilities for travel, and hence for wider observation, and last, though not least, to the action taken by the scientific press. It has become plain that teaching which does not forget the future occupation of the taught is as valuable educationally as the curiculum devised by the most ardent supporter of the dead languages. We are of the opinion that the system pursued in these modern universities is indeed better, in that the teaching is more or less applicable to the immediate surroundings of the scholars, increasing, as it does, their knowledge of Nature and Nature's laws, and leading them to investigate phenomena which under the older conditions would remain without interest. We have classed the City and Guilds Institute with the other institutions named, but it is scarcely a fair classification; its work, as originally framed, was a development of that of the Science Department at South Kensington.

The special object of this article is to call attention to a branch of work at the Finsbury College which has, so to speak, brought a new class within the range of its teaching power, and so far has proved eminently successful. The new departure is to be found in the courses of "Special Lectures." The majority of students attending these special lectures were found last year to differ entirely from those attending the other lectures. They were men actually engaged in the work about which the special lectures were intended to give information. Two of the special courses to be given this year are "Electrical," and are given by the principal of the College, Prof. S. P. Thompson. That on "Electric Bells" consists of six lectures, commencing October 7; that on "Electro-Deposition of Metals" commences on November 18. Both these courses are intended to appeal to practical men, and so far as we can judge from the syllabus they will do so. The former course is suited to a much wider audience than the latter, and it would be well if the London householder could be brought to the lecture room. He will hear therein how simple it is to protect his house, how easy and cheap it is to arrange electrical circuits and bells, so that no door or window of a house can be opened after a certain hour by an outsider, or, for the matter of that, by any one inside the house, without an alarm being given. Many people who ought to know better have the idea that an alarm circuit of this kind could be rendered useless by breaking the circuit—for example, by cutting one of the wires. We are so accustomed in England to use the open circuit that we forget the value of a closed circuit, and students attending these lectures will no doubt be made fully conversant with the advantages and the disadvantages of both systems. In both the courses mentioned we notice that supplementary laboratory work is connected with the course. This is the only method by which it can be ascertained if his audience has really understood the lecturer. In order to obtain the greatest advantage the hand as well as the ear must be educated; and as special apparatus is we understand provided at Finsbury for such laboratory practice, we can recommend those desirous of becoming better acquainted with the subjects mentioned to attend the lectures. The proprietors of large, well-organised electro-depositing works may probably fail to see the value of such a course of lectures as the one referred to; but when we consider there are hundreds, if not thousands, of places, where attempts at plating or other form of electro-deposition are made on a very small scale, and in which failure is more often the result than success, we shall be better able to value the information given during such a course. A few hints as to the necessity of cleanliness, and how to obtain it, the strength of current, the time required for a particular class of work, the strength of various solutions, all well known in large works, are little appreciated by the class of workers for whose benefit these lectures are intended, till pointed out and impressed upon them by a

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long series of failures. Forewarned is forearmed, and hundreds of these humble workers will be glad to receive instruction that will enable them to guard against failure.

CORRESPONDENCE.

THE ELECTRIC LIGHT IN SPAIN.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of 27th August, under the heading of "Notes," I notice the following paragraph:—"Where are the Electric Light Companies?" Your correspondent states that the only alternative offered to the Spaniards with regard to illumination is gas. This is certainly an error, as there are at least four different electric light companies in this country. The people, however, know but little of incandescent lighting, and seem afraid to embark in the speculation. The following proposition was made to the writer some short time back by one of the principal municipalities in Spain, viz., to pay the whole amount of contract four years after date of starting the lighting, and if a breakdown were to occur in said time of four years, the whole claim to be forfeited. You will see from this that it is not so easy to push electric lighting in Spain as your correspondent imagines.—Yours, &c.,

JAMES A. SELBY.

Anglo-American Brush Company, Bilbao, Sept. 4.

THE TELEPHONE SYSTEM.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: If there has been an invention within the last twenty years that has shown itself especially capable of large development and application to great usefulness and convenience that invention is undoubtedly the telephone.

When an accurate and quick working system has been offered to the business man in any of our towns, he has long ago recognised it as a means of saving both time and money; but when through some fault in either the subscriber's instrument or the exchange apparatus, or else inattention on the part of any of the operators, any one of these conditions of success (accuracy and speed) disappear, the service then becomes to the subscriber "more nuisance than it is worth;" and hence we have loud complaints against the company, and also find a serious falling off in the number of subscribers.

That this is the case we have, unfortunately, too many proofs; and it is through seeing a "Note" in your last week's issue with reference to the unsatisfactory condition of the Lisbon telephone system that I address these few lines to you.

As one who has had considerable experience in both the manufacture of the instruments and the working of the telephone system, I venture to assert, Sir, that fully 60 per cent. of the faults and irregularities which now occur are preventible.

In some cases a system of false economy on the part of the managers is the main cause. So-called inspectors are engaged at a low rate of wages, many of whom have acquired but the most elementary ideas of the laws of electricity and of the working of the various instruments which they may be called upon to inspect. It may seem to be an exaggerated statement, but I can vouch for the truth of it, that the bell of an instrument has been reported "out of order" by an inspector when the real fault has been "dead earth on line." In many cases he has not sufficient knowledge of the instrument to find the fault, and feels that he must report something, and the consequence is many instruments are sent in to be repaired described as having some fault which upon examination is found not to exist at all. I am afraid that I may seem harsh upon our friends the inspectors, but such is not my idea. The fault is really in those being engaged who are incompetent to do the work. The manager cannot expect for the low money which he offers to obtain the services of a thoroughly competent man.

Then, again, there is not always such a rig'd system of careful inspection as is absolutely necessary that there should be. By this I mean an inspection to prevent faults in batteries, contacts, and connections.

The exchanges also require, I am afraid, in many cases more systematic management to enforce instant attention on the part of the operators.

It may not be a panacea for every evil, but in the great majority of cases good management will be found to be the remedy.

I could name a district in England where, to within a short time since, the cause of the telephone was rapidly declining; but since an energetic, qualified manager has taken charge there things are improving in every way, and we hear from time to time of the rapid and wide extension of the system in the towns of that district.

Apologising for trespassing so largely on your valuable space. Yours, &c., TELEPHONE.

THE REGENT BATTERY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As a practical user of electric light by primary batteries, I have read with much interest an account of Macquay's battery—now called the Regent battery. I do not know if this battery has been tested further than the exhibition of *twenty-four* small cells, which are said to have run a 40-volt lamp with a light of *about* 12 candles for six hours!

I observe that many battery makers employ small cells with somewhat intricate fittings and connections, which mean trouble to the attendant after the run is over.

Batteries, of course, are made small to suit certain purchasers, but my experience tells me that the larger the cells are *in reason*, the better work they perform, and the more light they give.

For the past three years I have lighted my principal rooms and part of the parish church by primary batteries of my own making, although in possession of both steam and water-power. My experience with these batteries is such that I can confidently recommend them. They certainly yield a beautiful, luxurious, and perfectly steady light.

I have not found the cost excessive or the management irksome.

The wear and tear of the zincs appear to be in proportion to the light given. The use of an alloy is no novelty, but I think if it is used more cells are necessary. My last "run" with *one charge* of Sullivan's chromic acid mixture, which the firm are good enough to prepare me, has lasted for 54 hours, and the battery is still possessed of sufficient power to run sundry reading lamps without being enough to light the rooms.

The battery consists of 12 cells, and supplies currents for six 8 candle-power 16-volt lamps (one under water in an ornamental aquarium on the dining table) for the dining room, two 20-volt 12 candle power lamps in the hall, thirteen 5 candle-power 10-volt lamps in the drawing room, and four 8 candle power 16-volt lamps in the orangery.

The lamps are turned on where required. Naturally towards the end of the run the battery gets somewhat weaker, and will not light so many lamps at one time, but its constancy is remarkable. The cells are as simple as they can be, and any man or boy can attend to them. As I hope to show some of these cells in town later on in the season, I will not trouble you with a description.

As far as my knowledge goes, I think it is cheaper to use primary batteries alone rather than in connection with secondary, though much may be done by a judicious combination of the two.

Secondary batteries are apt to go wrong when not in constant use. With apologies for troubling you with this.—Yours, &c., CHARLES PENRUDDOCKE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In Dr. Fleming's report on the Regent battery it is stated that "40 watt hours can be obtained at the cost of 1d.," but no particulars are given as to how this cost is arrived at.

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Perhaps Dr. Fleming will kindly inform us if it includes the waste of zinc and charge left after the E.M.F. and current have been too much reduced to render the remaining latent energy of any practical value, or if it is based simply on the rate of consumption during the time the cells were working to their best advantage.

There is always a difficulty in arriving at the true merits of a primary cell, and I think a few simple questions properly answered would be of more value than the series of isolated facts generally given.

If, for instance, the following questions were duly replied to, we should be in a position to judge the comparative excellence of any primary cell.

1st. What is the working cost in watt hours per 1d. ? The price to include total charge, and the cell to work till either its E.M.F. or current has been reduced by a certain percentage of its original value (the percentage to be taken at, say, 10 per cent., or any other convenient figure to be agreed upon).

2nd. What has been the output in watt hours whilst the cell has been working under the conditions stated above ?

3rd. What are the total number of hours the cell has been working ? and what has been the mean current during that time ?

4th. Has the cell been working continuously ? and if not, what were the successive periods of rest and work ?

5th. What is the ratio between weight of cell and output as above ?

6th. Are any fumes emitted ? and if so, what are they ?

7th. What is the cost of cell, including charge ?—Yours, &c.,

N. G. THOMPSON.

TO THE EDITOR OF THE ELECTRICIAN.

SIR : My attention has been called to a statement in the prospectus of the Regent Portable Electric Light Company to the effect that "numerous batteries have been introduced to the public, and none of them are of any practical commercial use."

Will you be so good as to allow me to state that "The Standard Electric Light and Power Company" has been maintaining numerous installations in London and elsewhere of from 10 to 35 lamps each at a fixed price per lamp per annum for nearly a year past. In one instance, where there are 25 lamps, the light has been running continuously for over ten months, and during the last five months the gas has been completely cut off, which is the best evidence of its excellence and reliability. The recharging of the batteries, which is required at intervals of from ten days to two months, according to the amount of light used, is entirely undertaken by this company and carried out on a thoroughly organised system, so that the consumer has merely to turn the light on and off as he has been accustomed to do with gas. The results which we have achieved are so satisfactory both to ourselves and to our customers that we are now making arrangements for extending the business in London on a very large scale.—Yours, &c.

C. A. REEVE, Secretary.

8, Great Queen-street, Westminster, S.W., Sept. 8, 1886.

THE BRITISH ASSOCIATION MEETING.

PRESIDENTIAL ADDRESS.

(Continued from page 350.)

Keeping in view these general conclusions, let us now turn to their bearing on the origin and history of the North Atlantic.

Though the Atlantic is a deep ocean, its basin does not constitute so much a depression of the crust of the earth as a flattening of it, and this, as recent soundings have shown, with a slight ridge or elevation along its middle, and banks or terraces fringing the edges, so that its form is not so much that of a basin as that of the shallow plate with its middle a little raised. Its true permanent margins are composed of portions of the over-crust folded, ridged up and crushed, as if it be lateral pressure emanating from the sea itself. We cannot, for example, look at a geological map of America without perceiving that the Appalachian ridges, which intervene between the Atlantic and the St. Lawrence valley, have been driven bodily back by a force acting from the east, and that they have resisted this pressure only where, as in the Gulf of St. Lawrence and the Catskill region of New York, they have been protected by outlying masses of very old rocks, as, for example, by that of the island of Newfoundland and that of the Adirondack Mountains. The admirable work begun by my friend and fellow-student Professor James Nicol, followed up by Hicks, Lapworth, and others, and now, after long controversy, fully confirmed by the recent observations of the geological survey of Scotland, has shown the most intense action of the same kind on the east side of the ocean in the Scottish highlands ; and the more widely distributed Eozoic rocks of Scandinavia may be appealed to in further evidence of this.*

If we now inquire as to the case of the Atlantic depression, we must go back to a time when the areas occupied by the Atlantic and its bounding coasts were parts of a shoreless sea in which the earliest gneisses or stratified granites of the Laurentian age were being laid down in vastly extended beds. These ancient crystalline rocks have been the subject of much discussion and controversy, and as they constitute the lowest and probably the firmest part of the Atlantic sea-bed, it is necessary to inquire as to their origin and history. Dr. Bonney, the late President of the Geological Society, in his anniversary address, and Dr. Sterry Hunt, in an elaborate paper communicated to the Royal Society of Canada, have ably summed up the hypotheses as to the origin of the oldest Laurentian beds. At the basis of these hypotheses lies the admission that the immensely thick beds of orthoclase gneiss, which are the oldest stratified rocks known to us, are substantially the same in composition with the upper or siliceous magma or layer of the under-crust. They are, in short, its materials either in their primitive condition or merely rearranged. One theory considers them as original products of cooling, owing their lamination merely to the successive stages of the process. Another view refers them to the waste and rearrangement of the materials of a previously massive granite. Still another holds that all our granites really arise from the fusion of old gneisses of originally aqueous origin, while a fourth refers the gneisses themselves to molecular changes effected in granite by pressure. These several views, in so far as they relate to the oldest or fundamental Laurentian gneiss, may be arranged under the following heads :—(1) *Endoplutonic*, or that which regards all the old gneisses as molten rocks cooled from without inward in successive layers.† (2) *Exoplutonic*, or that which considers them as made up of matter ejected from below the upper-crust in the manner of volcanic action.‡ (3) *Metamorphic*, which supposes the old gneisses to arise from the crystallisation of detrital matter spread over the sea bottom, and either igneous or derived from the decay of igneous rocks.§ (4) *Chaotic* or *Thermo-Chaotic*, or the theory of deposit from the turbid waters of a primeval ocean either with or without the aid of heat. In one form this was the old theory of Werner.‖ (5) *Crenitic* or Hydro-thermic, which supposes the action of heated waters penetrating below the crust to be constantly bringing up to the surface mineral matters in solution and depositing these so as to form felspathic and other rocks.¶

It will be observed, in regard to these theories, that none of them supposes that the old gneiss is an ordinary sediment, but that all regard it as formed in exceptional circumstances, these circumstances being the absence of land and of sub-aerial decay of rock, and the presence wholly or principally of the material of the upper surface of the recently hardened crust. This being granted, the question arises, Ought we not to combine these several theories and to believe that the cooling crust has hardened in successive layers from without inward ; that at the same time fissures were locally discharging igneous matter to the surface ; that matter held in suspension in the ocean and matter held in solution by heated waters rising from beneath the outer crust were mingling their materials in the deposits of the primitive ocean ? It would seem that the combination of all these agencies may safely be invoked as causes of the pre-Atlantic deposits. This is the eclectic position which I endeavoured to maintain in my address before the Minneapolis Meeting of the American Association in 1883, and which I still hold to be in every way probable.

A word here as to the metamorphism, a theory which, like many others, has been first run to death and then discredited, but which to the moderate

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* Address to the Geological Section, by Prof. Judd, Aberdeen Meeting, 1885. According to Rogers, the Crumpling of the Appalachians has reduced a breadth of 158 miles to about 60.

† Naumann, Phillips, Durocher, M'Farlane, &c.

‡ Clarence King, Tornebohm, Marr, &c.

§ Lyell, Kopp, Reusch, Judd, &c.

‖ Scrope, Delabeche, Daubrée.

¶ Hunt, *loc. sit.* The following is Dr. Hunt's summary statement of this theory :—"The globe consolidating at the centre left, it is conceived, a superficial layer of basic silicates, which has yielded all the fixed elements of the earth's crust. This layer formed the first land and the floor of the primeval sea, the acid waters of which, permeating and partially decomposing it, became thereby chemically neutralised. This last cooled layer, mechanically disintegrated, saturated with water, and heated by the central mass, was the source of mineral springs, holding in solution the silicates which built up the ancient gneisses and similar rocks. Granitic veins and zeolites are due to survivals of the process which generated the gneissic rocks. The hypothesis of their formation from materials brought to the surface by mineral springs from the primitive basic layer affords, it is claimed, the elements of a complete and intelligible explanation of the origin of the Eozoic rocks. This upward lixiviation of the primitive mass, and the deposition over it of an acidic granite like rock, would leave below a highly basic material, and the division of the mass thus established would correspond to that of the trachytic and doleritic magmas, which have been conjectured to be the sources of two great types of eruptive rocks. Inasmuch, however, as according to the present hypothesis these two layers of basic and acidic matters are the results of aqueous action, and not of an original separation in a plutonic mass, as imagined by Phillips and Durocher, their composition would be subject to many local variations."

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degree in which it was originally held by Lyell is still valid. Nothing can be more certain than that the composition of the Laurentian gneisses forbids us to suppose that they can be ordinary sediments metamorphosed. They are rocks peculiar in their origin, and not paralleled unless exceptionally in later times. On the other hand, they have undoubtedly experienced very important changes, more especially as to crystallisation, the state of combination of their ingredients, and the development of disseminated minerals,* and while this may in part be attributed to the mechanical pressure to which they have been subjected, it requires also the action of hydrothermic agencies. Any theory which fails to invoke both of these kinds of force must necessarily be partial and imperfect.

But all metamorphic rocks are not of the same character with the gneisses of the Lower Laurentian. Even in the Middle and Upper Laurentian we have metamorphic rocks, *e g.*, quartzite and limestone, which must originally have been ordinary aqueous deposits. Still more in the succeeding Huronian and its associated series of beds, and in the Lower Palæozoic, local metamorphic change has been undergone by rocks quite similar to those which in their unaltered state constitute regular sedimentary deposits. In the case of these later rocks it is to be borne in mind that, while some may have been of volcanic origin, others may have been sediments rich in undecomposed fragments of silicates. It is a mistake to suppose that the ordinary decay of stratified siliceous rocks is a process of kaolinisation so perfect as to eliminate all alkaline matters. On the contrary, the fact, which Judd has recently well illustrated in the case of the mud of the Nile, applies to a great number of similar deposits in all parts of the world, and shows that the finest sediments have not always been so completely lixiviated as to be destitute of the basic matters necessary for their conversion into gneiss, mica-schist, and similar rocks when the necessary agencies of metamorphism are applied to them, and this quite independently of any extraneous matters introduced into them by water or otherwise. Still it must be steadily kept in view that many of the old pre-Cambrian crystalline rocks must have been different originally from those succeeding them, and that consequently these last, even when metamorphosed, present different characters.

I may remark here that, though a palæontologist rather than a lithologist, it gives me great pleasure to find so much attention now given in this country to the old crystalline rocks, and to their study microscopically and chemically as well as in the field, a work in which Sorby and Allport were pioneers. As a pupil of the late Professor Jameson, of Edinburgh, my own attention was early attracted to the study of minerals and rocks as the stable foundations of geological science ; and as far back as 1841 I had learnt of the late Mr. Sanderson, of Edinburgh, who worked at Nicol's sections,† how to slice rocks and fossils ; and since that time I have been in the habit of examining everything with the microscope. The modern developments in this direction are therefore very gratifying to me, even though, as is natural, they may sometimes appear to be pushed too far or their value over-estimated.

That these old gneisses were deposited not only in what is now the bed of the Atlantic, but also on the great continental areas of America and Europe, anyone who considers the wide extent of these rocks represented on the map recently published by Professor Hull can readily understand.‡ It is true that Hull supposes that the basin of the Atlantic itself may have been land at this time, but there is no evidence of this, more especially as the material of the gneiss could not have been detritus derived from sub-ærial decay of rock.

Let us suppose, then, the floor of old ocean covered with a flat pavement of gneiss, or of that material which is now gneiss, the next question is how and when did this original bed become converted into sea and land. Here we have some things certain, others most debatable. That the cooling mass, especially if it was sending out volumes of softened rocky material, either in the exoplutonic or in the crenitic way, and piling this on the surface, must soon become too small for its shell, is apparent ; but when and where would the collapse, crushing, and wrinkling inevitable from this cause begin ? Where they did begin is indicated by the lines of mountain chains which traverse the Laurentian districts ; but the reason why is less apparent. The more or less unequal cooling, hardening and conductive power of the outer crust we may readily assume. The driftage unequally of water-borne detritus to the south-west by the bottom currents of the sea is another cause, and, as we shall soon see, most effective. Still another is the greater cooling and hardening of the crust in the polar regions, and the tendency to collapse of the equatorial protuberance from the slackening of the earth's rotation. Besides these the internal tides of the earth's substance at the times of solstice would exert an oblique pulling force on the crust, which might tend to crack it along diagonal lines. From whichever of these causes, or the combination of the whole, we know that within the Laurentian time folded portions of the earth's crust began to rise above the general surface in broad belts running from N.E. to S.W., and from N.W. to S.E., where the older mountains of Eastern America and Western Europe now stand, and that the subsidence of the oceanic areas allowed by this crumpling of the crust permitted other areas on both sides of what is now the Atlantic to form limited table-lands.§ This was the beginning of a process repeated again and again in subsequent times, and which began in the Middle Laurentian, when for the first time we find beds of quartzite, limestone, and iron ore, and graphitic beds, indicating that there was already land and water, and that the sea, and perhaps the land, swarmed with animal and plant life of forms unknown to us, for the most part, now. Independently of the questions as to the animal nature of Eozoon, I hold that we know, as certainly as we can know anything inferentially, the existence of these primitive forms of life. If I were to conjecture what were the early forms of plant and animal life, I would suppose that just as in the Palæozoic the acrogens culminated in gigantic and complex forest trees, so in the Laurentian the algæ, the lichens, and the mosses grew to dimensions and assumed complexity of structure unexampled in later times, and that in the sea the humbler forms of Protozoa and Hydrozoa were the dominant types, but in gigantic and complex forms. The land of this period was probably limited, for the most part, to high latitudes, and its aspect, though more rugged and abrupt, and of greater elevation, must have been of that character which we still see in the Laurentian hills. The distribution of this ancient land is indicated by the long lines of old Laurentian rock extending from the Labrador coast and the north shore of the St. Lawrence, and along the eastern slopes of the Appalachians in America, and the like rocks of the Hebrides, the Western Highlands, and the Scandinavian Mountains. A small but interesting remnant is that in the Malvern Hills, so well described by Holl. It will be well to note here and to fix on our minds that these ancient ridges of Eastern America and Western Europe have been greatly denuded and wasted since Laurentian times, and that it is along their eastern sides that the greatest sedimentary accumulations have been deposited.

From this time dates the introduction of that dominance of existing causes which forms the basis of uniformitarianism in geology, and which had to go on with various and great modifications of detail, through the successive stages of the geological history, till the land and water of the northern hemisphere attained to their present complex structure.

So soon as we have a circumpolar belt or patches of Eozoic* land and ridges running southward from it, we enter on new and more complicated methods of growth of the continents and seas. Here we are indebted to Le Conte for clearly pointing out that our original Eozoic tracts of continent were in the earliest times areas of deposition, and that the first elevations of land out of the primeval ocean must have differed in important points from all that have succeeded them ; but they were equally amenable to the ordinary laws of denudation. Portions of these oldest crystalline rocks, raised out of the protecting water, were now eroded by atmospheric agents, and especially by the carbonic acid then existing in the atmosphere perhaps more abundantly than at present, under whose influence the hardest of the gneissic rocks gradually decay. The Arctic lands were subjected in addition to the powerful mechanical force of frost and thaw. Thus every shower of rain and every swollen stream would carry into the sea the products of the waste of land, sorting them into fine clays and coarser sands ; and the cold currents which cling to the ocean bottom, now determined in their courses, not merely by the earth's rotation, but also by the lines of folding on both sides of the Atlantic, would carry south-westward, and pile up in marginal banks of great thickness, the *débris* produced from the rapid waste of the land already existing in the Arctic regions. The Atlantic, opening widely to the north, and having large rivers pouring into it, was especially the ocean characterised, as time advanced, by the prevalence of these phenomena. Thus throughout the geological history it has happened that, while the middle of the Atlantic has received merely organic deposits of shells of Foraminifera and similar organisms, and this probably only to a small amount, its margins have had piled upon them beds of detritus of immense thickness. Prof. Hall, of Albany, was the first geologist who pointed out the vast cosmic importance of these deposits, and that the mountains of both sides of the Atlantic owe their origin to these great lines of deposition, along with the fact, afterwards more fully insisted on by Rogers, that the portions of the crust which received these masses of *débris* became thereby weighted down and softened, and were more liable than other parts to lateral crushing †

Thus in the later Eozoic and early Palæozoic times, which succeeded the first foldings of the oldest Laurentian, great ridges were thrown up, along the edges of which were beds of limestone, and on their summits and sides thick masses of ejected igneous rocks. In the bed of the central Atlantic there are no such accumulations. It must have been a flat, or slightly ridged, plate of the ancient gneiss, hard and resisting, though perhaps with a few cracks, through which igneous matter welled up, as in Iceland and the Azores in more modern times. In this condition of things we have causes tending to perpetuate and extend the distinctions of ocean and continent, mountain and plain, already begun ; and of these we may more especially note the continued subsidence of the areas of greatest marine deposition. This has long attracted attention, and affords very convincing evidence of the connection of sedimentary deposit as a cause with the subsidence of the crust.

We are indebted to a French physicist, M. Faye,‡ for an important suggestion on this subject. It is that the sediment accumulated along

* The first of these is what Bonney has called *Metastasis*. The second and third come under the name *Metacrasis*. *Methylosis*, or change of substance, is altogether exceptional, and not to be credited except on the best evidence, or in cases where volatile matters have been expelled, as in the change of Hematite into Magnetite, or of bituminous coal into anthracite.

† And I believe at Witham's also. ‡ *Trans.* Royal Irish Academy.

§ Daubrée's curious experiments on the contraction of caoutchouc balloons, partially hardened by coating with varnish, show how small inequalities of the crust, from whatever cause arising, might affect the formation of wrinkles, and also that transverse as well as longitudinal wrinkling might occur.

* Or Archæan, or pre-Cambrian, if these terms are preferred.

† The connection of accumulation with subsidence was always a familiar consideration with geologists ; but Hall seems to have been the first to state its true significance as a geological factor, and to see that those portions of the crust which are weighted down by great detrital accumulations are necessarily those which, in succeeding movements, were elevated into mountains. Other American geologists, as Dana, Rogers, Hunt, Le Conte, Crosby, &c., have followed up Hall's primary suggestion, and in England, Hicks, Fisher, Starkie Gardiner, Hull, and others, have brought it under notice, and it enters into the great generalisations of Lyel on these subjects.

‡ *Revue Scientifique*, 1886.

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the shores of the ocean presented an obstacle to radiation, and consequently to cooling of the crust, while the ocean floor, unprotected and unweighted, and constantly bathed with currents of cold water, having great power of convection of heat, would be more rapidly cooled, and so would become thicker and stronger. This suggestion is complimentary to the theory of Prof. Hall, that the areas of greatest deposit on the margins of the ocean are necessarily those of greatest folding and consequent elevation. We have thus a hard, thick, resisting ocean-bottom which, as it settles down toward the interior, under the influence of gravity, squeezes upward and folds and plicates all the soft sediments deposited on its edges. The Atlantic area is almost an unbroken cake of this kind. The Pacific area has cracked in many places, allowing the interior fluid matter to ooze out in volcanic ejections.

It may be said that all this supposes a permanent continuance of the ocean-basins, whereas many geologists postulate a mid-Atlantic continent* to give the thick masses of detritus found in the older formations both in Eastern America and Western Europe, and which thin off in proceeding into the interior of both continents. I prefer, with Hall, to consider these belts of sediment as in the main the deposits of northern currents, and derived from Arctic land, and that, like the great banks of the American coast at the present day, which are being built up by the present Arctic current, they had little to do with any direct drainage from the adjacent shore. We need not deny, however, that such ridges of land as existed along the Atlantic margins were contributing their quota of river-borne material, just as on a still greater scale the Amazon and Mississippi are doing now, and this especially on the sides towards the present continental plateaus, though the greater part must have been derived from the wide tracts of Laurentian land within the Arctic Circle or near to it. It is further obvious that the ordinary reasoning respecting the necessity of continental areas in the present ocean basins would actually oblige us to suppose that the whole of the oceans and continents had repeatedly changed places.

(To be continued.)

THE BLACKPOOL ELECTRIC TRAMWAY.†

BY M. HOLROYD SMITH.

Without treating generally of electricity as a locomotive power, the object of the present paper is to deal with the special difficulties and conditions arising when it is used for propelling street tramcars. If the cars were running upon a track reserved exclusively for their use, the work would be simple; but in a street other vehicular traffic has to be considered, and not only have numerous Board of Trade conditions to be complied with, but local authorities and householders have also to be consulted and satisfied.

General Conditions.—The general conditions are three: firstly, safety to the public; secondly, efficiency; and thirdly, economy. With some reservations, the first condition may be accomplished by the employment of secondary batteries, which are destined to play an important part in the progressive development of electricity for tractive purposes; but it must be admitted they occupy only a

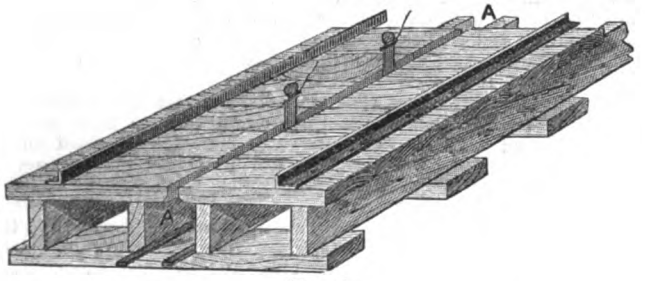
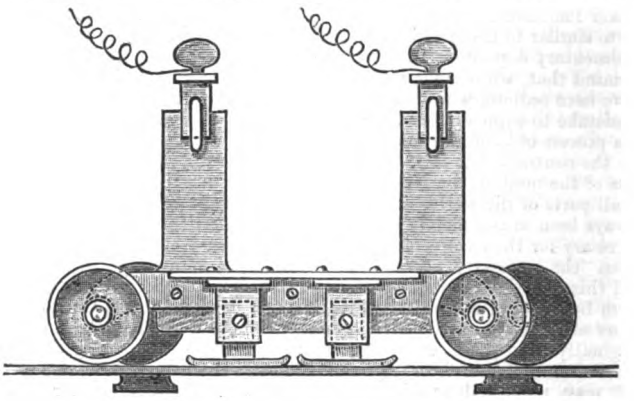


FIG. 1.

secondary place, when it is shown that electricity can be used direct, and can then fulfil not only the first condition, but the other two also. The employment of the rails as lead and return conductors is out of the question; for in large installations it must fail in regard to all three conditions. Side fence-rails or overhead conductors, though fulfilling the conditions of efficiency and economy, are inadmissible for street purposes. There seems, therefore, but one course, and that is to place the electric conductors underground. This position involves many difficulties, some on first consideration apparently insurmountable.

Before the construction of the Blackpool electric tramway, many progressive experiments were made; they have already been described and published elsewhere, and therefore it will not be necessary to give a detailed account of them here; a brief reference to two will probably be sufficient. The first track laid was only 18in. gauge, and was for convenience made of wood. It is shown in Fig. 1. The channel A contained two copper strips, one of them being the lead and the other the return conductor. The collector trolly which ran upon them is now exhibited, and is shown in Fig. 2. The employment of separate conductors within the channel A, though possessing some advantages, is open to many objections. The chief of these is the cost, because each strip must be of large enough section to carry the whole current. The next objection is risky insulation; and the third is difficulty of dealing with points and crossings. Separate conductors were therefore



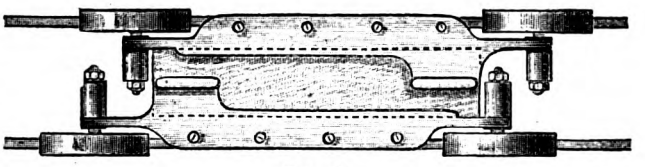
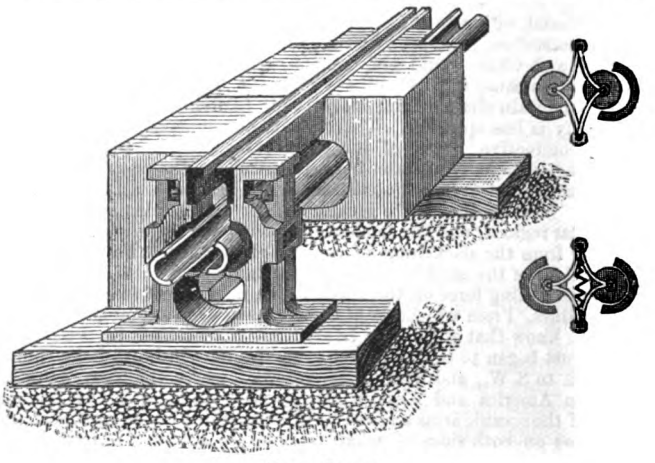


FIG. 2.

abandoned, and many modifications were designed, including a tubular conductor with an expanding shuttle travelling within it, an arrangement admirably suited for single lines, but inapplicable for one with branches, loops, and crossings.

The first full-gauge line was laid in a field near Manchester, and was 110 yards long. A section of the channel is shown in Fig. 3, and models are exhibited. Here the conductor consisted of two half tubes, held in insulating supports; and the collector, shown in Fig. 4, was composed of two spirally fluted rollers, so held that they



FIGS. 3 & 4.

expanded and constantly pressed against the inside of the two half tubes, and maintained good contact with them, and by revolving cleared away any accidental obstruction that might be within the hollow open tubes. This action was all that could be desired; but the objection to the method was that, in attempting to clear the channel, mud and dirt were liable to be piled against the iron chair and conductor, thereby spoiling the insulation; and when once so piled, cleansing was a difficult and expensive process.

Requirements.—The conditions presenting themselves for solution are numerous, and may be classed as follows, according as they pertain to the conductors, to the motor, or to other general matters:—

* Among American geologists, Dana and Le Conte, though from somewhat different premises, maintain continental permanence. Crosby has argued on the other side. In Britain, Hull has elaborated the idea of interchange of oceanic and continental areas in his memoir in *Trans.* Dublin Society, and in his work entitled "The Physical History of the British Islands." Godwin-Austin argues powerfully for the permanence of the Atlantic basin, "Q. J. Geol. Society," Vol. XII., p. 42. Mellard Reade ably advocates the theory of mutation. The two views require, in my judgment, to be combined.

† Paper read before the British Association at Birmingham. This paper was originally prepared for the Institute of Mechanical Engineers, to which body Mr. Smith expressed his thanks for their aid in its preparation.

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Class A.—Conditions pertaining to the Conductors.

1. Protected electric conductors, so arranged that constant contact can be made and maintained, and yet not liable to damage.
2. Good and reliable insulation, free from fouling, and renewable in case of failure.
3. Facility for inspecting the whole length of the channel, if necessary.
4. Ready means of regularly cleansing the channel, removing the ordinary street dirt, or any unusual accumulation.
5. Provision for working points and crossings for pass-byes and branches, without short-circuiting or failing to make contact.

Class B.—Conditions pertaining to the Collector.

6. Provision for making and maintaining contact between the motor on the car and the conductors within the channel.
7. Avoidance of damage, either electrical or mechanical, should the collector become blocked.
8. A construction of collector that will preserve its insulation and take the points of the turn-outs without fouling them.

Class C.—Conditions pertaining to the Motor.

9. A design and construction of electric motor, capable of withstanding the sudden and severe strains to which it will be subjected in working.
10. Gearing between the motor and the car-axles that shall work as smoothly and silently as possible, and with little loss in transmission.

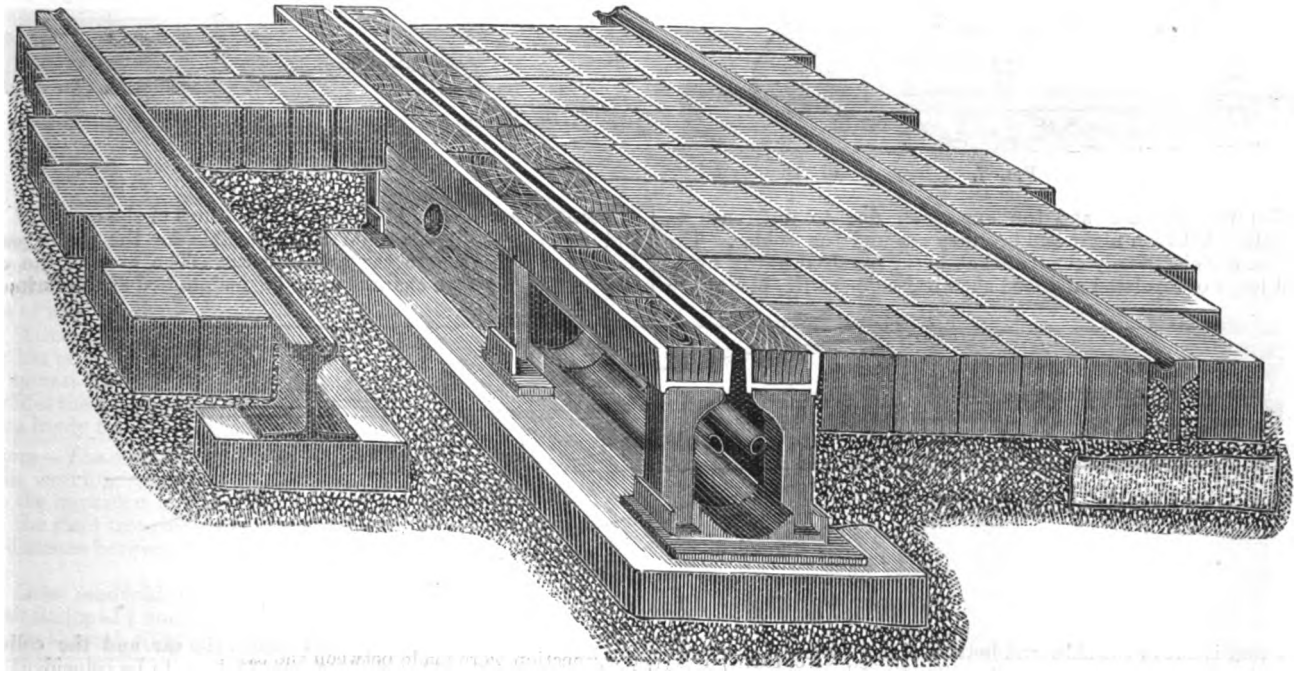

FIG. 6.

11. Electrical and mechanical fittings so arranged that the car can be driven in either direction from either end.
12. Freedom from complication, so that the whole of the machinery can be understood and managed by an ordinary workman.
13. Provision against serious damage in the case of any mistake being made by the driver.

Class D.—General Conditions.

14. Generation and control of the electricity; provision for a variable production; prevention of damage through short-circuiting; and avoidance of lengthy stoppage in case of accident.

Description of Line.—The Blackpool line is nearly two miles in length, and the general plan of it is shown in Fig. 5.* It is a single track, with ten pass-byes and one length of double line. The engine-house and car-sheds are placed near the centre; this position was selected as being the most convenient, and as offering considerable advantages from an electrical point of view, compared with a generating station at one end. The roadway runs along the sea coast, facing directly west and exposed to the full force of the wind and tide from the Irish Sea. So strong are the periodical storms that, though the road-level is well above ordinary high-water mark, the waves dash over in such volumes that the road is flooded, and the doors and windows of the houses are occasionally beaten in; during the winter months it is the custom to board up the doorways of many houses on the south shore. The difficulties in applying electricity underground in such a situation are therefore unusually great. When the tide is over the line, the current of course makes earth. At one time it was intended to employ accumulators for haulage during the flooding, and horses were occasionally used; but owing to the amount of shingle brought over, the grooves in the rails were filled, and the cars kept running off. Working during the floodings has therefore been abandoned.

These circumstances and others afterwards to be mentioned pointed to the necessity of allowing any dirt or shingle that might enter the slit in the surface of the centre channel to fall through freely to the bottom, and also of providing for its easy removal. The sump holes and traps for this purpose are placed at the points marked SS on the plan, and have direct drains connecting them with the sea, advantage being taken of the town drains used for running off the surface water. In Fig. 6 is shown a part section of the roadway in perspective; and in Fig. 7 is shown a transverse section of the channel A; including the cast-iron chair B; the channel steel C forming the cover, which is called "steel troughing" in order to avoid confusion of terms; the side woods D holding the insulators E; and the copper conductors F. The chairs are of cast iron, 11in. high with a 12½in. base and an internal width of 5½in.; the bottom is rounded, and the ends have pockets for holding the side boards. These chairs are placed every yard, and support the steel troughing, which is bolted to their surface; the nuts are covered and locked by a cast-iron cap. The rest of the troughing is filled with wooden blocks, and forms so good a paving that the horses prefer it to the rest of the road. The sides of the troughs are inclined, so that when fixed the space between them is ½in. at the top and 1in. at the bottom, the object being that any stone having once passed the surface may easily fall through, instead of getting hopelessly jammed.

Creosoted wood is used for the sides, with a view to adding to the insulation. The wood sides have a 2½in. hole bored midway between the chairs, for the reception of the porcelain insulator; and ¾in. holes are bored at right angles for the insertion of a wooden peg, which, passing through the groove in the insulator, locks it fast. This method has added greatly to the facility of construction. The roadway under the side pieces is packed; and the centre is concreted, and tooled to form the same curvature as the bottom of the chair.

In Fig. 8 is shown an enlarged view of the insulator or stud; and also the manner of supporting the copper conductors and securing them by the insertion of the wooden pins P. The conductors are made of hard drawn copper, having a conductivity of 96 per cent. of pure copper; they are in lengths of 36ft., and weigh almost exactly 1lb. per foot. They are placed at the angle shown, firstly for convenience in fixing, secondly in order that the collector may partially rest upon them as well as press against them, and thirdly in order that any dirt coming between them and the side boards or chairs may easily fall through.

Tubes.—The tubes are connected one with the other by wedges made of drawn brass, exactly fitting the inside of the tube. Space

* This figure is not given, as it is not necessary for the due understanding of the paper.

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is left between the ends to allow for expansion and contraction ; and the wedges are secured from shifting by a wrapping of wire. In the first few hundred yards laid the wedges were soldered ; but the operation was difficult, and the expansion due to difference in temperature between night and noonday cracked the solder. The two tubes are electrically conducted at every hundred yards by U shaped loops of insulated and lead sheathed copper wire, placed in a groove that is cut in the sides and bottom of the channel. Over each of these loops, as marked on the plan, is a hand hole, which is made by cutting both of the steel troughs and filling the place with two pieces of a yard length, which are protected by suitable side plates. These hand holes are needful for many purposes, specially for the insertion of the scrapers used in cleaning the channel, and for the removal of collectors, should they become damaged or require adjustment. Only the positive electricity passes along the copper conductors. The return circuit is made by means of the rails ; and to ensure its being electrically good, each rail is connected by a strip of copper passing from rail to rail and plugged into holes punched in the ends.

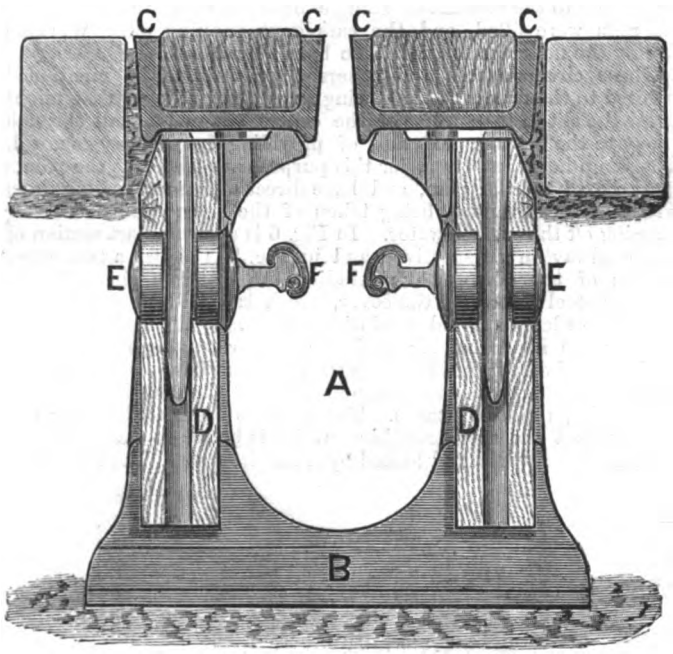

FIG. 7.

Points.—Dealing with the points necessitated by the numerous pass-byes was a matter of no small difficulty ; for in tramways it is desirable that the rail points forming the turn-outs should be as fine as possible, so as to avoid strains and joltings of the cars. If well and properly laid, it should be impossible for the passengers to detect the places where the points occur. The area of the cross section of the centre channel must be maintained at the fork ; and if a rigid connection were made between the car and the collector underground, the channel points would have to be coincident with the rail points, and the surface slit in the channel to remain central between the two rails, which would involve such a long overhanging tongue as to be impracticable. The employment of a flexible connection between the car and the collector renders possible the arrangement shown in Fig. 9, where it will be seen that, while the rail points are fine, the channel point is wide, and is placed some distance back, and that the rail and channels cross each other at a nearer approach to a right angle than would otherwise be possible, thus minimising what would be a structural weakness.

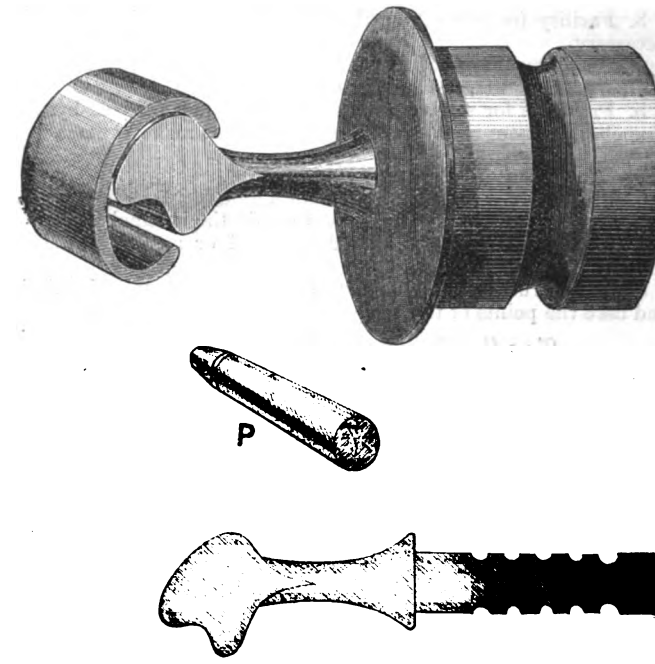

FIG. 8.

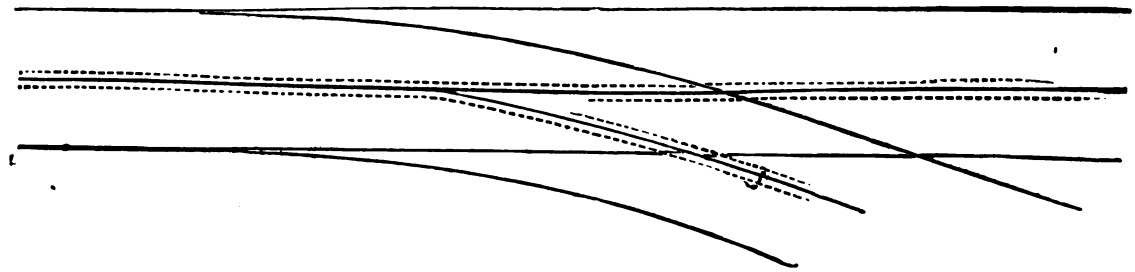

FIG. 9.

FIG. 10.

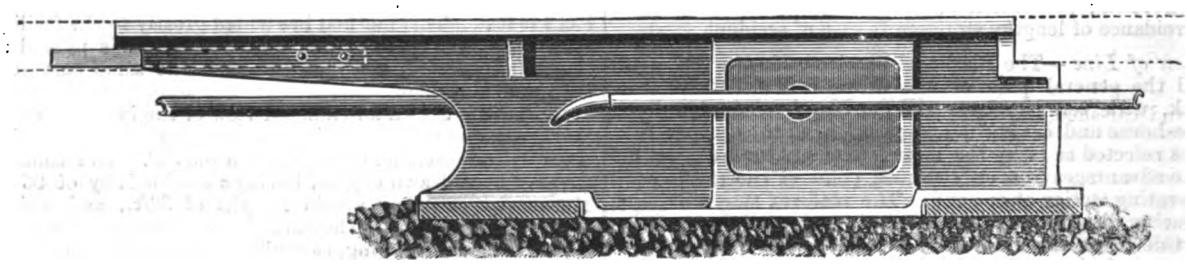

FIG. 11.

In Fig. 10 is shown a side elevation of the point ; and in Fig. 11

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a plan illustrating the arrangement of the conductors. The two copper tubes, which have been running parallel with each other in the single channel, here part company, taking the outer position in the channel of the loop line; and they are there joined by subsidiary

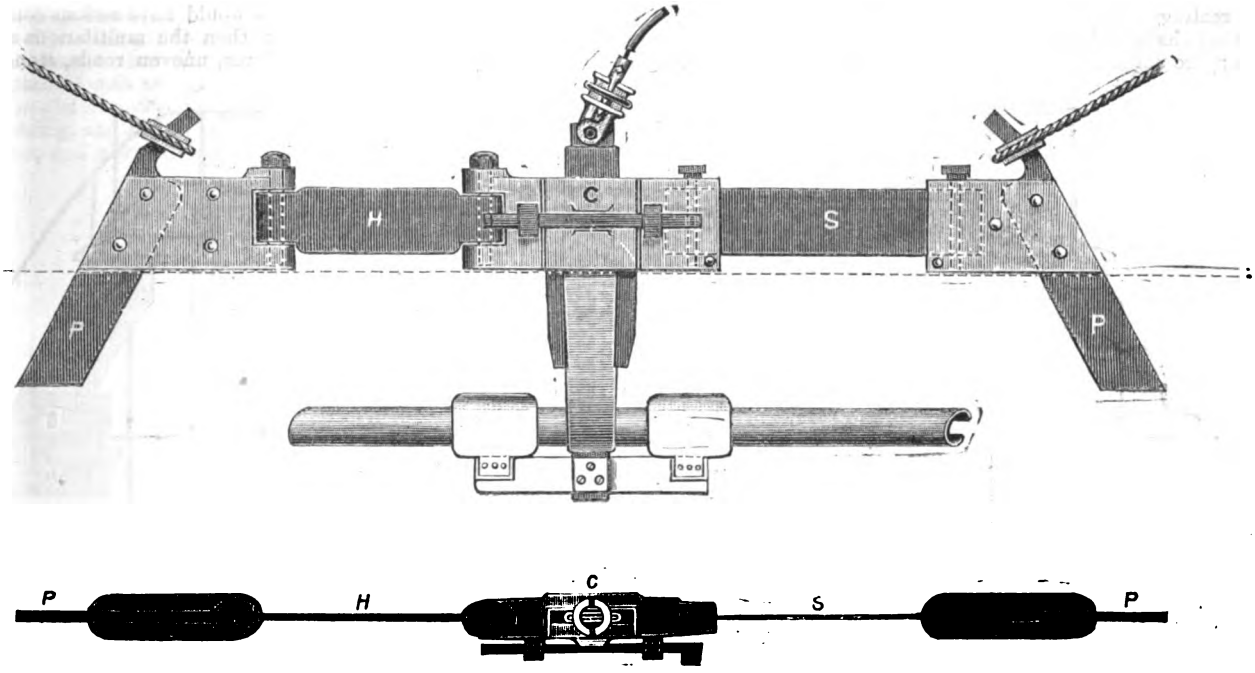

FIG. 12.

tubes, which are electrically connected with the outer or main tubes by one or more of the insulated loops previously described. In order to prevent the collector from fouling when taking the points, the ends of these secondary tubes are fitted with brass horns, as shown. Although the lay of the channel points is such that the collector has no tendency to take the wrong way, yet for further security against such a mishap a steel spring, S, is placed at the toe, which guides the collector to the proper side in taking the points, and opens freely for allowing it to pass when leaving.

Collectors.—The collectors have been perhaps the chief source of trouble in working, partly from inherent faults, but principally owing to the imperfect laying of the line; the ½in. slit or opening between the steel troughing was not even approximately accurate, and the distance between the two conductors was most distressingly variable.

These facts rendered it impossible to use a collector of the form first designed; and it would be wearisome to describe the many stages through which this instrument passed before the form now in use was developed. Samples are exhibited, and are illustrated in Figs. 12 and 13. The collector consists of three main parts, namely, one centre-piece, C; and two clearing ploughs, PP, for enabling it to run in either direction. As already stated, one of the elements of success in working electric tramways with conductors underground is the employment of a flexible collector, flexibly connected. For this purpose the two ploughs are joined to the centre-piece either by a tempered steel strip, S, or by a hinged wrought-iron plate, H, Figs. 12 and 13. The tempered steel plates forming the ploughs are held by cast-iron cheeks, and are placed at the angle shown, and extend downwards a little past the bottom of the steel troughs; their upper ends terminate in a prong or finger, curved slightly backwards. The fingers receive the loop or ring of the hauling ropes which are attached to the front and rear of the car. The ropes are strong enough to stand considerable strain, and their ends are fitted either with a releasing clip, or with a short loop of weaker cord, which is strong enough to bear the stress due to any ordinary obstruction; but should an absolute block occur, then the small loop breaks, or the clip lets go, and the collector is left behind, while the car travels forward. At the same time the ring of the trailing rope slips off the finger of the rear plough; if this were not so, the force required to break the loop of the trailing rope would make the collector kick up, and would cause the contact-making part of the centre-piece to short-circuit with the underside of the steel troughing. The centre piece consists of a cast-iron cheek, holding a plate of strong brass, which is thoroughly insulated and protected by hardened steel guards where it passes through the troughing. The bottom of the insulated plate is bared of insulating material, and has attached to it either a short plate of brass, or two brass wires, forming a T, and holding at each end hard metal wings specially prepared; the forward wing is bent so as to press against the left-hand conductor tube, and the rear one is bent so as to press against the right-hand tube. To the upper end of the insulated plate is fixed a clip, surrounded by an india rubber ring; the clip is bored to receive a heart-shaped terminal, which can be easily pushed into

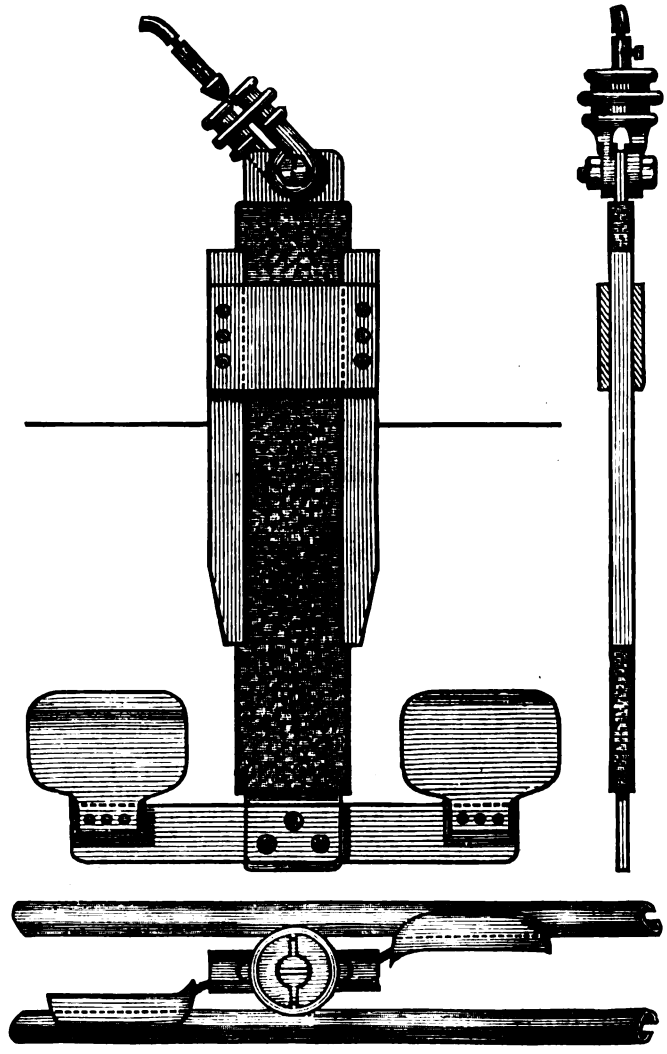

FIG. 13.

it, but requires a fair natch to withdraw it. A similar clip is fixed to the receiving wire under the car; and a short length of curled

insulated wire with a heart-shaped terminal at each end makes a ready connection between the collector and the car.

Cars.—The cars are ten in number, and of various designs. The smallest are light open summer cars, seating thirty passengers. The largest are provided with transverse seats on the roofs, and carry fifty-six passengers. In Figs. 14 and 15 is illustrated a medium size, seating forty-eight. As shown in the plan, the levers of the ordinary chain-brake are placed outside the wheels, so as to leave a clear space under the centre of the car for the motor and the gearing. The mechanical construction of the motor M was specially designed for allowing it to be fixed in the position shown. The bearings are held in a circular frame, large enough for allowing the armature to be passed through it.

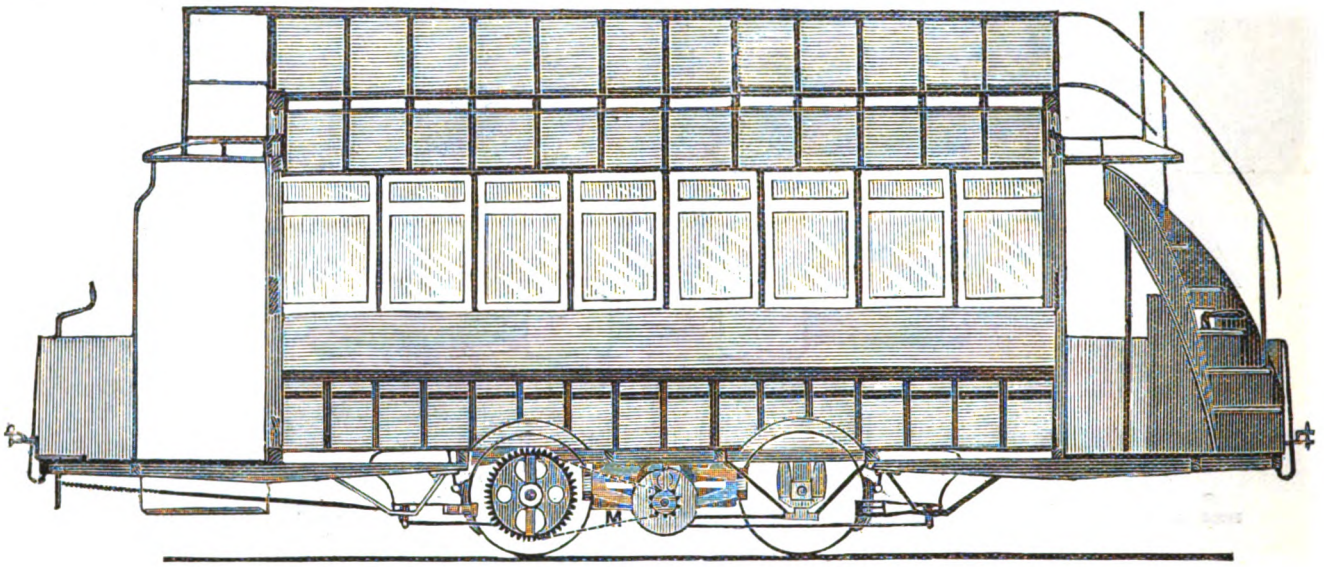

FIG. 14.

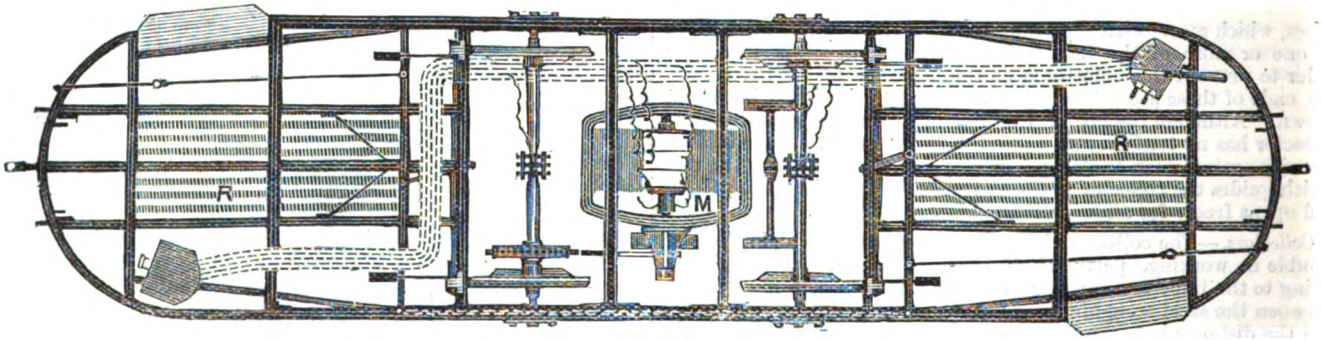

FIG. 15.

Motors.—The motors are series-wound, and of such proportions that they yield a high efficiency, running in either direction without giving any lead to the brushes. Reversal is effected by changing the internal coupling; that is to say, whilst the current through the field is always in one direction, the current through the armature can be reversed, thus changing the relative polarity and consequent direction of motion. Ordinary brushes were found to give constant trouble, due not only to this reversal, but also to the jolting of the car, &c. Many other forms were tried without success before the simple device illustrated in Fig. 16 was adopted, which is found to act remarkably well. Each brush consists of a thin steel plate, SS, insulated from the studs DD, and free to work on them. The steel plates are divided into fingers, which carry little blocks made of a special metal and capable of being easily renewed. The blocks are made to press against the commutator by small bands of india rubber stretching from tip to tip of the fingers. The pressure of the brushes is thereby regulated and equalised, and the vibration and jolting are compensated.

Gearing.—To the circular frame of the motor is bolted the base of an elbow bracket, which carries the invert wheel gearing into a gunmetal pinion on the end of the armature spindle. The box holding the invert wheel has upon its back a chain pinion, from which the power is taken to the large wheel keyed upon the axle of the car. The elbow bracket can be turned upon its base, so as either to slacken or tighten the chain at pleasure, without moving the motor or disarranging the centres of the armature pinion and invert wheel. But for the inevitable stretching of the chain, and the noise when new, this gear would be all that could be desired.

The electric driving of a tramcar involves more than the mere question of the reduction from high to low velocity. The wheels have to drive the car, not the car to take the wheels; but as the car is heavier than the wheels, it is therefore better that the driving power should come from the car. If the motor were attached to the axles in order to obtain a fixed relation between the driving and the driven wheel, then the vibration would have serious consequences. If the motor be fixed to the car, then the multifarious movements due to varying load, springs, curves, uneven roads, stones, &c., all of which disturb the relation between the driving and the driven wheel, have to be compensated for. It has been argued that worm

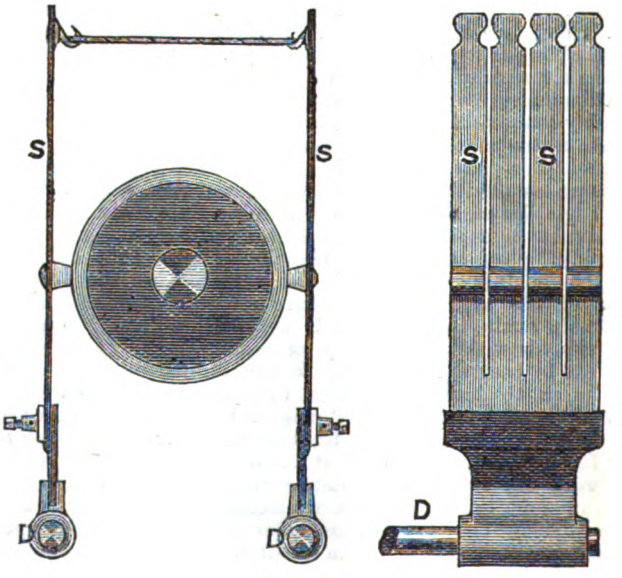

FIG. 16.

gearing is the most convenient for reducing a high velocity to a low one; and also, on the other hand, that the loss in friction is fatal to

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the economical use of worm gear. The employment of worm gearing is a problem for which the writer believes that no reliable data exist or can be formulated; it is a question of compromise, and the difficulty is to strike the happy medium. Experiments which he has made have given such satisfactory results that his intention is to adopt in future work the modification of worm gear which he has devised for the purpose.

Wiring.—The wiring of the cars is shown in strong dotted lines. In order to control the quantity of current and the consequent speed, resistance coils are placed at R, and are coupled with the switch boxes placed under the car steps. A removable handle is used for driving, and a plug switch for reversal; these are in charge of the driver, and when the car has completed its run in one direction he carries them to the other end of the car; this plan prevents any accidental derangement, as it is impossible for the switches to be worked without them. The coils are arranged in series, and their resistance is about 4 ohms; and most of the switches are of an ordinary type, cutting out 1 ohm at a time. This method is open to the objection that the changes are not sufficiently gradual; and if a heavy current is allowed to pass through the final coil for a considerable time, it may become dangerously hot. It seemed desirable, therefore, that the switch should be so arranged that the coils could be used first in series and then in parallel, in order to obtain a more gradual change, and secure a larger surface for radiation when little resistance was in. A switch accomplishing this object is exhibited.

Generating Station.—In Fig. 17 is shown a plan of the generating station. As the cars have to work all day, the engines and dynamos are in duplicate, each set being capable of doing the full ordinary work, while in case of need both can be used at once. The engines are 25 nominal horse-power, compound non-condensing, of the semi-portable type, with locomotive boilers. A second-motion shaft is employed, in order that either or both of the engines may drive either or both of the machines. The dynamos are placed on a higher level than the engines, which enables the wheels controlling the friction couplings FF to be placed in a position where they can be worked conveniently by the engine man.

Generators.—The generators are four-pole shunt-wound dynamos; but instead of allowing any current from their own armatures to pass round the field magnets, these are separately excited by the little machines MM. As the electromotive force of the external circuit varies directly with the intensity of the field, it can be regulated to a nicety by varying the resistance in the circuit of the exciter. This resistance is by preference placed in the armature circuit of the exciter, namely, between the terminals B and C in Fig. 18. If the resistance were placed in the field of the exciter, the regulation of the electromotive force in the external circuit would probably be more complete; but the magnets of the generators would then discharge through the armature of the exciter, and there would be an extra current due to breaking the circuit of the magnets of the exciter. These extra currents would have tendency to destroy the insulation, and would be otherwise injurious.

The controlling switch has ten points, and the corresponding resistances are as follows:—

Points.	Resistances.	Points.	Resistances.
1	21 ohms.	6	9 ohms.
2	18·5 ,,	7	6·8 ,,
3	16·1 ,,	8	4·8 ,,
4	14 ,,	9	2·4 ,,
5	11·5 ,,	10	0 ,,

The maximum electromotive force of the generators is 300 volts; and each will yield 180 amperes. They can when required be run in parallel. It is unnecessary to give the electrical details of these machines; but it may be mentioned that the total length of No. 17 wire (0·06in. thick) on the magnets of each generator is about fourteen miles.

In Fig. 19 the black curve shows the variation in the electromotive power of the exciter due to varying resistances when exciting one generator, and the red curve when exciting both.

In Fig. 20 is shown the varying electromotive force in the external circuit by the line when No. 1 generator is used, by the black line when No. 2 is used, and by the dotted line when both are excited in parallel.

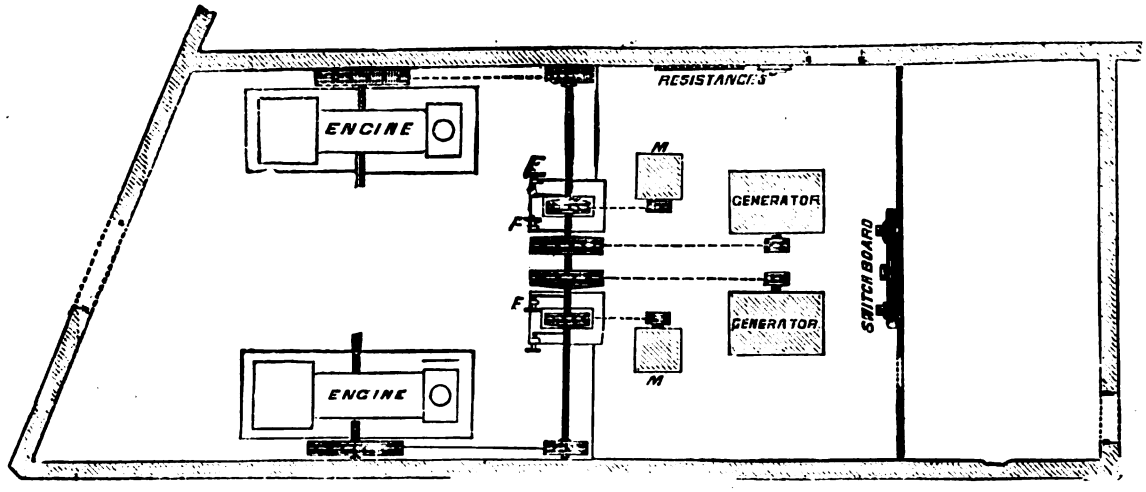

FIG. 17.—Generating Station.

Fig. 18 is a diagram of the instrument board, showing the arrangement of switches, voltmeter, ammeter, and cut-out. Fuses

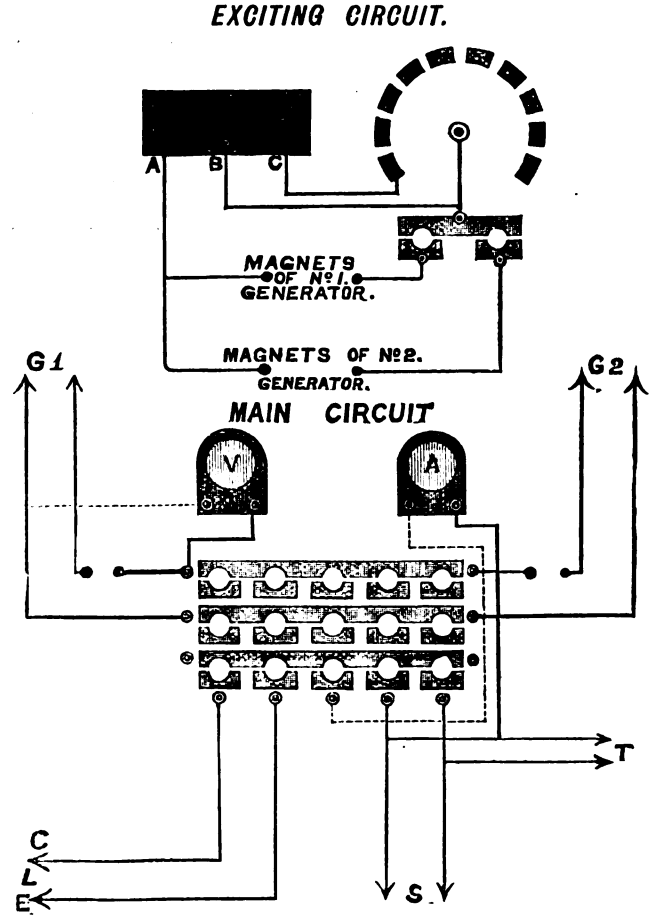

FIG. 18.

have been tried, instead of the cut-out; but their action was not rapid enough to avoid severe strains upon the generators, and flashing at the commutator when an absolute short-circuit occurred. A further advantage of a magnetic cut-out is that it can be easily

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regulated according to working requirements. Though a multiple-plug switch is somewhat too complicated for ordinary workmen, it forms in the hands of an experienced electrician a perfect means of regulating the direction of the currents from the two generators through the various instruments and to and from the line. A little watchfulness is necessary, especially before running both machines at the same time, as they have occasionally changed their polarity.

Conductivity.—The sectional area of each copper tube represents a solid conductor of 0·575in. diameter, giving a resistance of 0·165 ohm per mile. As there are two tubes running the whole length, and as the line runs right and left from the generating station, the total resistance may be taken as the joint resistance of two miles,

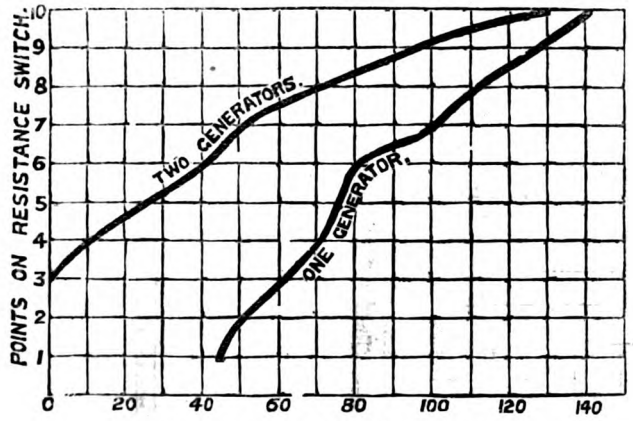


FIG. 19.

which brings the calculated resistance down to 0·041 ohm. The actual resistance is much more than this, as is evident from the fall of potential over the line, which is shown in Fig. 21. The readings are also marked upon the general plan in red figures at the places where they were taken, and are as follows :—

Tram Shed, the electromotive force usually employed of 220 volts.
Foxhall, the junction with the main line..... 210 ,,

Going North.		*Going South.*	
South Pier	207 Volts.	Manchester Hotel	204 Volts.
Royal Hotel	204 ,,	Wellington-road ...	198 ,,
Lane Ends Hotel...	198 ,,	Alexandra-road ...	189 ,,
Bailey's Hotel	189 ,,	Waterloo-road	174 ,,
North End	185 ,,	South End	168 ,,

This fall is probably due to poor joints, faulty connections, etc.

Insulation.—Measurements were taken of the insulation of the line during construction, and 150 yards' length was found to give 4,490 ohms. But it has been practically impossible to measure the insulation of the finished line ; for when the current is off, the condensation and moisture upon the insulators make the resistance very small. This, after a night of heavy rain or sea flood, causes a serious loss. When commencing work in the morning sometimes as much as 100 amperes is absorbed ; but after running the engines for, say, half an hour, the leakage will fall to 30 amperes. The average working loss through leakage may be taken at 25 amperes, which at an electromotive force of 220 volts is equal to 7·2 horse-power. The principal difficulty arises from the shingle brought over by the tides, and the large quantity of fine sand blown into the channel by the high winds. At the commencement much trouble and annoyance resulted from the faulty construction previously referred to ; but now by watchfulness and adjustment any hindrance to working can be avoided.

Efficiency.—No reliable measurements have been taken to ascertain the total percentage of loss in transmission, starting with the indicated horse-power of the engines and the mechanical power developed in propelling the cars. To arrive at this percentage it would be necessary to take a given number of cars of known weight, filled with passengers of known weight also, and to run them at the same time upon a given length of line of known gradient. When planning the works the writer assumed that the efficiency would be only 30 per cent. ; but from the observations taken and the calculations of the different quantities, the actual efficiency is believed to be nearer 45 per cent. As the efficiency of the generators is about 90 per cent. and of the motors about 80 per cent., much further economy must not be looked for in them ; though it should be possible for the loss in the generator to be not more than 5 per cent. and in the motor 10 per cent. The second-motion shaft in the present arrangement fulfils too important an office to be dispensed with ; though by special engines and gearing the same object could be attained with less friction. It is exceedingly doubtful whether any form of gearing can be devised to absorb less power in transmission than that already described ; indeed, a larger percentage of loss might be allowed for the sake of simplicity and silence. The chief part, therefore, in which to look for further economy is the line itself ; and in this the first point is more perfect insulation, and, consequently, less loss in leakage ; and the next is more

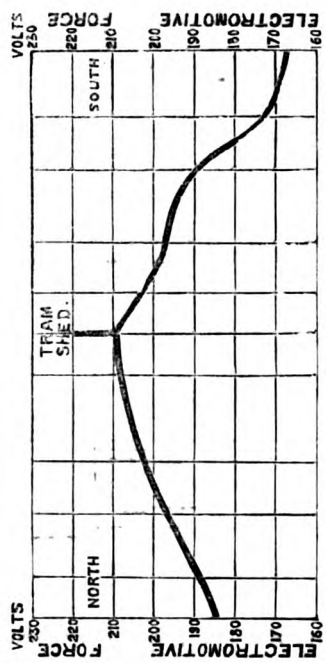


FIG. 21.

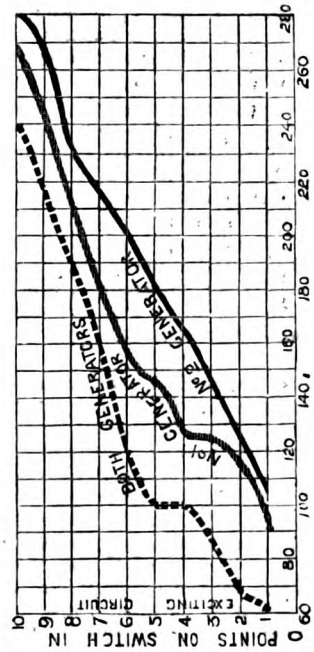
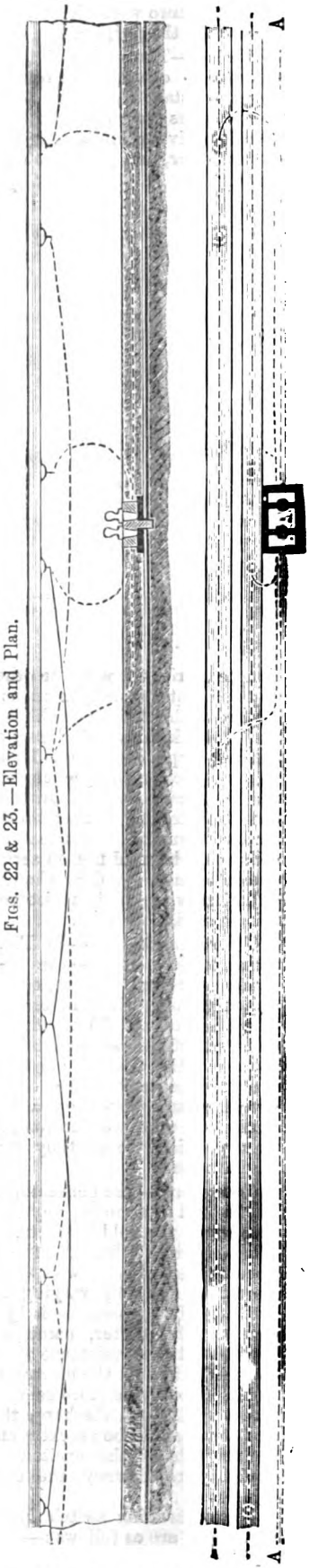


FIG 20.



FIGS. 22 & 23.—Elevation and Plan.

perfect continuity in the conductors, and therefore less loss through resistance.

When larger installations are undertaken, considerations other than those already mentioned have to be faced. How it is proposed

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to deal with these in the future may be suggested by reference to Figs. 22 and 23. Here AA is an insulated cable running the whole length of the line, tapped at regular distances to supply different sections of exposed conductors; each tapping should be covered by a switch controlling two lengths. The conductors should consist of wires or ropes, swung from the surface of the channel, instead of being supported at the sides, thus dispensing with at least 75 per cent. of the insulators, and also placing the insulators where they would be more accessible in case of failure. By alternating the points of support of the wires, and allowing the collector to run under instead of over or against them, better contact may be maintained. By making the sectional area of the channel wider, the risk of filling will be lessened and cleansing will be rendered easier; and by increasing the width of the surface slit even ¼in., the life of the collector would be materially prolonged, and its insulation better secured.

Discussion.

Mr. Horsefall (Chairman of the Blackpool Electric Tramway) said he was not aware until a few minutes before he came into the room that Mr. Smith was going to read a paper. He thought it his duty, as Chairman of the line in question, to endorse what Mr. Smith had said in respect to the difficulties that had been overcome, and which had resulted from the bad way in which the channels and other work had been executed by the engineers. As to the question of the economy of working the line, he had been at the trouble to take out some figures which might be interesting. For the week ending June 4th, their receipts were £67. 1s. 1d., and the working expenses had been £30. 18s. 4d., which included coal, tallow, waste, fireman's wages, as well as those of conductors, collectors, and inspectors of the line. For the last four weeks their receipts had averaged £330 per week, and the cost of material, wages, and everything else, had been about £45 in round figures. Their total receipts since the opening of the line to August 27th, were £4,038. 16s. 1d. That was including the winter months, when, he was sorry to say the receipts did not pay the cost of working. He was in hopes, however, that during the coming winter, now that they had got over many of their difficulties, they would be able to pay the cost of working and make a profit for the shareholders. Personally, although he was not an electrician, as Chairman of the Company, he had had a good deal to do with it, and he must certainly endorse the views set forth by Mr. Smith that morning. He believed that there was a great future for electric tramways in this country if they were properly managed. They had gained experience at Blackpool, unfortunately, at a considerable cost to the Company, which had spent in round figures about £30,000, in laying down the line; but he was quite sure that if another tramway were to be constructed, it could be done at a considerably less sum. He concluded by moving a vote of thanks to Mr. Smith for his valuable paper.

Mr. Douglas Galton said he had listened with great interest to what Mr. Holroyd Smith had had to say in his valuable paper. He would have liked, however, to hear a rather more detailed explanation of the cost of working such tramways; but as the lines had been put down so very recently he imagined it would be rather difficult to get what would be a fair and reliable estimate of the working expenses. The system employed at Blackpool was not the only form of electric traction on tramways in operation. At Antwerp last year—and he understood that there were several carriages of the same kind put on to the tramways at Brussels now in active operation—the tramcars were worked by means of accumulators. He confessed that at first sight he thought that such a system, if it could be proved to be economical, would be preferable, because it did not seem to involve so large an outlay in the first instance, and he supposed there must be a certain expense in keeping the conductors clean. Perhaps Mr. Smith would say what that expense amounted to. He did not know that the experiments at Brussels had gone so far as to determine whether the system was a satisfactory means of traction. Certainly, at Antwerp the results were very satisfactory, but as the lines there were on perfectly level ground, and no hills had to be gone up, he did not think that those results could be taken as a fair guide of what the expenses might ordinarily be expected to be. In Brussels, on the other hand, the ground was hilly, which was a serious difficulty, but if it were found that the tramways there could be worked at a reasonable expense, notwithstanding the inclines, he thought that, as the result, very great additions might be expected to be made to electrical traction on tramways. They were of course just now in the experimental stage of the question, but there was one point which he thought was quite certain, and that was that most people would prefer to have electrical traction, which was most agreeable on tramways, rather than steam or horse-power, if it could be obtained at anything like a reasonable cost.

Another Speaker said he wished to allude for one moment to a remark Mr. Smith had made with regard to the sand on the line. He happened to have lived by the seaside a great number of years, and he knew that there was hardly anything more calculated to fill up all kinds of space than sand when the weather was dry and the wind happened to be blowing from the sea. After a gale of wind, when the sand was in a dry condition, it seemed to find its way into every cavity. Under such circumstances, he had found the rain pipes on his house filled from top to bottom, so that when rain fell it could not run through them at all, and it appeared to him that with a strong wind blowing the working of the line might be seriously interfered with on that account. In the course of his reply perhaps Mr. Smith might say whether the tramway had suffered from that or not.

Sir Frederick Bramwell asked what was the number of amperes required for the work.

Mr. Tait said he was acting as county surveyor of Antrim at the time when the Giant's Causeway line was constructed and when the electric tramway was being made there, and he could not help thinking that £30,000 for a couple of miles of line at Blackpool was a very great outlay for so small an undertaking. The question of providing electricity for tramcars, if it was not to be carried by the cars themselves, was one of very great importance for the future of that kind of locomotion. He did not think that the costs of the experiments both at the Giant's Causeway and on the line now under consideration could be fairly considered safe data to go upon, as they were merely tentative. There was one point in connection with the underground supply system which he would like to get more information about, and that was with reference to the clearing of the space in which the conductors were placed. What were the frequency and the means adopted for clearing it?

Prof. Perry desired to offer his congratulations to Mr. Smith on the success which his system seemed to have attained. No outsider knew the difficulties that an inventor met with in carrying out electro-mechanical inventions in the present state of electrical engineering. Mr. Smith was therefore to be congratulated—quite irrespectively of any cost of his electrical tramway—on being able to work it at all, because he had had to face very great obstacles. He (the speaker) confessed that the track was rather an expensive one. That method of making a track seemed to be very good where there would be no accumulation of sand likely to take place, but it was certainly a most expensive one. Along with Prof. Ayrton he (the speaker) had patented certain contrivances which, in their opinion, would enable electric tramways to be worked efficiently. They had, however, got off just now on a side issue in a slightly different direction in the development of some of those patents which came under the name of telpherage; and when one took up any particular line of investigation one had absolutely no time to turn one's attention into other channels of discovery. One of the important contrivances that he referred to was one in which there was no opening whatever into the space where actual contact was made, the contact being effected from the tramcar outside. The internal contact of the actual conductor was made in the space to which nothing had access from the outside. Both in London and in Paris tramcars had been run by means of accumulators, and at the time Prof. Ayrton and he ran them the weight—he would not say the cost—but certainly the weight of the accumulators was prohibitive. Perhaps some of the gentlemen present might be able to say to what extent the weight of accumulators and their cost had been reduced, so as to make that plan of driving the tramcars encourage the hope of its meeting with any decent chance of success. He felt that the most important thing that any electrical engineer—he thought he might say any mechanical engineer—could devise for the benefit of humanity would be a motor which should have, he would not say any defects electrically, but which should have no defects mechanically. The way in which a man who might know electricity perfectly from a theoretical point of view, but who was ignorant of the mechanical knowledge necessary to give it practical effect, sometimes carried out his work was simply absurd. It could therefore be easily seen what mismanagement sometimes arose when an electrician had charge of an invention. Some of the telegraph engineers present might have noticed that Mr. Holroyd Smith said that the insulation resistance of the line was between 4,000 and 5,000 ohms. He (the speaker) considered that that figure was a very good one for a tramway system. If a telegraph engineer would only figure out to himself how small an amount of power was being wasted in comparison with the tremendous power that was used, he would see that such a resistance was very satisfactory indeed. If that amount of power were wasted on a telegraph line, no message would be sent, but on a tramway its loss was not to be considered as of any moment.

Mr. Leech believed from what he had seen of electric tramcars that they were perfectly under the control of those conducting them, and that they could not only travel with safety at a much quicker speed than steam cars, but they could be stopped almost instantaneously, while they were superior in this, that they were self-contained—not as in the case of the steam locomotive having an engine in front and the car behind, but having their accumulators stowed away under the seats. The accumulators, moreover, had been so much reduced in weight, that the objection had practically disappeared. As far as he had been able to ascertain, tramcars driven by accumulators were a decided success, and he thought it was highly desirable now to try and discover its merits as compared with the plan now set before them by the paper they had listened to on that occasion.

Mr. Gisbert Kapp drew attention to the fact that by the diagrams exhibited the loss of power was as great as 40 volts out of 200, which he characterised as being exceptionally heavy. He wished to know whether that would be the case under what would be considered to be satisfactory working conditions. Prof. Perry had referred to the fact that a great desideratum was a perfect mechanical motor. He (the speaker) had been of that opinion for a very long time, and had done his best to make one, but had failed. He wanted to know whether the gearing on the Blackpool service, which was evidently adapted for reducing speed considerably, was found to be in all respects satisfactory for working the tramway. What it was now chiefly desirable to get in connection with electric tramways was a high speed motor with noiseless and efficient gearing.

Mr. Holroyd Smith, in reply, said that he was afraid if he replied fully to the numerous questions which had been addressed to him, his replies would occupy as much time as his paper. One of the first that occurred to him was that asked by Sir Frederick Bramwell. If Sir Frederick would kindly look through one of the papers he would find the information he desired respecting the number of amperes employed. The E.M.F. of the generating machines could be regulated to a nicety. Their

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maximum power was 300 volts and 100 amperes each, so that when they were running parallel they got plenty of current for the work. He found that the cars would take 15 to 40 amperes—that was to say, 40 when they were working up hill, and 15 to 20 when they were working on the ordinary roads. Mr. Kapp was perfectly correct in what he had stated in regard to the loss of power. The diagrams were not complimentary to himself as regarded the loss of E.M.F. He attributed the circumstance to the submersion of part of the line at certain periods in salt water. He quite agreed with Prof. Perry, to whom he was indebted for alluding to the fact, that they must not expect that high insulation in tramways—it was not necessary—that was required for telegraphs. In fact, the line in question would be, as far as insulation was concerned, practically good if the total insulation were only 100 ohms—quite good enough for practical purposes. The leakage when large currents had to be dealt with, such as in this case, of 250 to 300 volts—the resistance of 100 ohms was not of much moment. With regard to the system that Prof. Perry mentioned, namely, that of having a covered conductor and occasional contact made with it from the car, he (Mr. Smith) was not quite sure that he was acquainted with its details, but he knew the general idea of the plan, and he was afraid that Prof. Perry would find it almost impracticable if he put it into use. There were many practical considerations that were apt to be lost sight of when one was dealing with matters of this kind in the laboratory. He (Mr. Smith) was afraid that as soon as contact was made they would make earth, and so the current would be lost. Respecting the subject of having good motors, he must confess that he had no small difficulty with that matter. He was unfortunately only a mechanical engineer, and the electricians would not place any trust in him, the result being that he had to leave electrical matters to others much more than he ought to have done; but he had found that ultimately the designs first laid down by himself and rejected by the maker had to be accepted and worked upon before the motors were made with any practical success. If they desired to get a high electrical efficiency a great many mechanical questions which it appeared not at all desirable to sacrifice had to be done away with. They were now getting 80 per cent efficiency, and he held that to a great extent that was due to the simple contrivance he now held in his hand. Electricians had told him that it was out of the question to use such a thing as that. Now, however, there was little or no trouble with the brushes, and the commutators lasted for months, whereas they would not last for a week before. With respect to the gearing alluded to by Mr. Kapp and Prof. Perry, he must say that the gearing now working, but for the statement he had already made with respect to the noise and the stretching of the chain, would be perfectly satisfactory. The arrangements pretty well excluded the dirt, and he had been very careful about the teeth and the method of holding the wheel within its shell. There had been no broken teeth up to the present time. The chains had been the principal drawback, but when any difficulty had arisen from that it had been owing to an undue sense of economy on the part of the management. He had devised a worm gearing, and although he knew it sounded almost unorthodox amongst engineers to say so, one of the paragraphs in his paper showed that in his opinion the worm gearing was a subject upon which no reliable data existed, or could be stated. It was a question of compromise throughout, but if they could strike a happy mean, he thought with worm gearing they would have a great success. He really believed that properly designed worm gearing was going to be the most satisfactory for tramway work. That would give them what Mr. Kapp required, namely, a high speed motor and an absolutely quiet gearing. Mr. Horsefall, the chairman of the company, stated, and perfectly accurately, that the total cost of the Blackpool line was £30,000. Now, what he (Mr. Smith) had to deal with was not the cost of the line, but with the cost of the electrical part of the work. The whole cost of the channel, the engines and engine house, the generators, the wires, electric motors, the switches, instruments, &c., was under £12,000. As to the question of accumulators, he wished to state most emphatically that it was a delusion in the public mind that electricity was going to be put into a bucket the size of a hat, or only weighing about one cwt., and that then it was to do a great deal of work. A tramcar could not be worked with light accumulators. Supposing they had accumulators to work a line they would want three tons of them in each car, and they would have to be renewed three times a day. The total cost of fitting a line with accumulators would be 15 or 20 per cent. more than fitting it with a channel. The total cost of carrying 42,000 people in one week was under £45. He asked whether they could show in this or any other country a tramway worked at such a low rate. He was certain that it could not be done.

COMPANIES' MEETINGS.

The Manchester and District Edison Electric Light Company (Limited).

The annual meeting of this Company was held on Monday, the 6th inst., at the Memorial Hall, Albert-square, Manchester, Mr. V. K. Armitage (the chairman) presiding.

The fourth annual report stated that the results of the year's work compared favourably with those of any previous similar period in the history of the Company, there being a small profit instead of, as previously, a loss upon the twelve months' business. The long-pending actions against infringers of the incandescent lamp patents held in the Manchester district by the Company had since the last report been heard and determined in favour of the Edison and Swan United Company. Though notice of appeal had been given by the defendants in the actions, it was confidently believed that the judgment lately given would be sustained. Should that anticipation prove well founded there could be no doubt that the value of the Company's property would be considerably enhanced. Notice to refrain had been given to all known users of infringing lamps, and every effort to sustain the patent rights was being made by the parent Company. Inquiries as to the cost of installing the electric light were more numerous than at any previous time, and the prospect of work to be done in the immediate future was decidedly favourable. Since the close of the financial year the Directors had had to deplore the loss by death of their esteemed colleague, Mr. W. A. Turner.

The CHAIRMAN moved and Major FLOOD PAGE (London) seconded the adoption of the report and balance-sheet.

The motion was passed after some questions had been asked and answered.

On the motion of Mr. J. F. CHEETHAM, seconded by Mr. CHARLES MOSLEY, Mr. Armitage was re-elected Chairman.

Mr. J. J. ARMITAGE then proposed and Prof. HOPKINSON seconded the re-appointment of Messrs. Jones, Crewdson, and Youatt, accountants, Norfolk-street, Manchester, as auditors, which was passed.

Major TURNER moved and Mr. SYKES seconded a vote of thanks to the Chairman, which was carried unanimously.

The proceedings then terminated.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. SEPT. 8.		BUSINESS DONE WEEK ENDING SEPT. 8. Highest.		Lowest.	
Anglo-American	33,	34	.....	33½	.....	33¼
Do. Preferred	55,	56	.....	—	.....	—
Do. Deferred	10¾,	11¼	.....	11	.....	—
Brazilian Submarine	10¾,	11	.....	10¾	.....	10 11-16
Cuba	11,	11½	.....	—	.....	—
Do. Preference	18,	19	.....	—	.....	—
Direct Spanish	1½,	2	.....	—	.....	—
Do. Preference	9,	10	.....	10	.....	—
Direct United States Cable	8¾,	9¼	.....	9¼	.....	8 15-16
Eastern Telegraph	11⅛,	11⅜	.....	11⅜	.....	11 7-16
Do. 6 per Cent. Preference	14½,	14¾	.....	—	.....	—
Do. 5 per Cent. Debentures, 1899	105,	108	.....	106½	.....	—
Eastern Extension	12⅜,	12⅝	.....	12 9-16	.....	12⅜
German Union	9¼,	9½	.....	—	.....	—
Globe Telegraph and Trust	6⅜,	6⅝	.....	6¼	.....	6⅜
Do. Preference	13½,	13⅝	.....	13 5-16	.....	13¼
Great Northern	13,	13½	.....	13½	.....	13
Indo-European	36,	37	.....	37½	.....	36½
Reuter's	6¼,	7	.....	6¾	.....	6 9-16
Submarine	195,	205	.....	200½	.....	—
West India and Panama	⅛,	¼	.....	¼	.....	—
Do. 1st Preference	8¾,	9¼	.....	9¼	.....	8
Western Brazilian	6⅝,	6¾	.....	—	.....	—
Western Union 7 per Cent. 1st Mortgage	118,	122	.....	—	.....	—
Do. 6 per Cent. Sterling Bonds	104,	106	.....	—	.....	—

TELEPHONES.

Consolid. Telephone and Maintenance	13-16	15-16	.....	—	.....	—
Oriental	3-16	5-16	.....	—	.....	—
United Telephone	13¾,	14⅛	.....	14	.....	13¾

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	2,	2½	.....	—	.....	—
Do. (fully paid)	3¾,	4¼	.....	—	.....	—
Swan	¾,	1⅛	.....	—	.....	—
Maxim Weston	3-16	5-16	.....	¼	.....	—

MISCELLANEOUS.

Telegraph Construction	38½	39½	.....	39¼	.....	38¾
India Rubber, Gutta Percha, and Telegraph Works	23½	24½	.....	24¼	.....	23½

TRAFFIC RECEIPTS FOR AUGUST, 1886.

COMPANIES.	August, 1886.	August, 1885.	Increase.	Decrease.
Cuba Submarine	2,200	2,262	—	62
Direct Spanish Telegraph	1,370	1,326	44	—
Eastern Extension	34,687	41,987	—	7,300
Eastern Telegraph	44,091	47,968	—	3,877
Great Northern	22,400	—	—	—
West Coast of America	3,105	—	—	—

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BY GISBERT KAPP, C.E.

ARC and GLOW LAMPS.
BY JULIUS MAIER, Ph.D.

London: WHITTAKER & CO. Paternoster Square.

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NOTES.

THE WEST AFRICAN LINES.—Telegraphic communication has now been established with Lagos, Brass, and Bonny (West Africa).

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 10th inst. amounted to £3,116.

LUMINOUS RAIN.—*L'Astronomie* records a fall of luminous rain during a thunderstorm at Sotteville. That is to say the drops on touching the ground produced flashes of red and violet light. Similar phenomena have been previously recorded.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 10th inst. were £2,432, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

CHORLEY, LANCASHIRE.—Messrs. Sharples, of Preston, have received an order from the Chorley Board of Guardians to connect the workhouse hospital and the master's room by telephone, and the different wards and attendants' bed rooms by electric bells.

THE SCHARNWEBER LAMP.—The Scharnweber arc lamp, which was recently described and illustrated in our columns, is now made by the Woodhouse and Rawson Electric Manufacturing Company, who have acquired the sole rights for England and France.

ELECTRIC LIGHT AT CARDIFF.—A new arcade, containing forty-one shops, which has recently been opened in Queen-street, Cardiff, is lit by twelve Brush arc lamps, each of 2,000 candle-power. The installation has been carried out by the Anglo-American Brush Company.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended the 31st Aug. are £1,964, as compared with £2,358 in the corresponding period of 1885. The May receipts, estimated at £5,762, realised £5,764.

THE LIGHTING OF THE GENERAL POST OFFICE.—The Post Office has recently ordered two Elwell-Parker dynamos and two Willans engines, with which plant the lighting of certain portions of the premises of the General Post Office will now be carried out in a permanent manner.

GOSPORT AND THE ELECTRIC LIGHT.—An application having recently been made to the Alverstoke Local Board as to the lighting of Gosport by electricity, that authority has come to the conclusion that "the utilisation of the electric light for this purpose is not practicable in the parish."

THE LIVERPOOL ART GALLERY.—One of the rooms at the Walker Art Gallery, at Liverpool, is being fitted with electric light by the Liverpool Electric Supply Company, in view of the forthcoming Autumn Exhibition. If the arrangement gives satisfaction, the lighting will be extended to the whole of the galleries.

THE BLACKPOOL TRAMWAY.—During last week the number of passengers carried on the electric tramway at Blackpool was 44,306. The cost of fuel (coal and coke) was £4 16s. 3d., the total working expenses being £45. 16s. 2d., while the total receipts were £347. 15s. 3d., and the total distance run 2,760 miles.

BIRKDALE PALACE HOTEL, SOUTHPORT. — The Maxim-Weston Company has just completed an installation of the electric light in this hotel. The installation consists of 200 incandescent lamps of 20 candle-power, and 5 arc lights of 1,600 candle-power. The latter are placed in the ball room and grounds.

A NEW THEORY OF THUNDERSTORMS.—Herr L. Solenche having shown experimentally that the friction of ice and water results in the positive electrification of ice, and consequent negative electrification of water, considers it probable that the friction of cumulus and cirrus clouds, may be sufficient to account for thunderstorms.

ELECTRIC LIGHTING IN MADRID.—We learn from the *Imparcial* that the electric light continues to make progress in Madrid. The experiments recently made by the Sociedad Matriteuse de Electricidad for lighting the Mercantile Club by incandescent lamps having proved satisfactory, that institution is now lighted permanently by 100 Swan lamps.

THE PARIS-CREIL EXPERIMENTS.—M. A. Gravier, writing on this subject to the French scientific press, shows that the quantity of material used in the construction of the generator at Creil, would have been sufficient to furnish with the same current four times the number of volts which were actually obtained, if employed in building Gramme machines of the ordinary "A" type.

ELECTROMOTOR WORKING IN THE STATES.—It is understood that some of the American Companies have decided to supply electric power on the rental system, after the example of the owners of the Bell Telephone patents, and will discourage the sale of their motors out-right. In view of the large number of motors in the market, it is difficult to see what is to be gained by such a policy.

"TECHNICAL" JOURNALISM IN THE STATES.—One of our esteemed transatlantic contemporaries, evidently wishing to be complimentary, thus refers to a certain successful electrician:—"He is a fat and jolly scalper, who can yell like a Comanche, but who is believed to be good for $200,000, and weighs about two hundred and fifty pounds." We take it that this is about perfect of its own kind.

ELECTRICITY IN THE GRAVE-YARD.—At Brooklyn a society is being formed to insure its members against the horror of being buried alive. For the first six months after apparent death the bodies are to lie in unclosed coffins, placed in a large chamber, which will be provided with electric signals for communicating with the world without. It has been suggested that a connection should be made with the Telephone Exchange.

RECENT PROGRESS IN ARBORICULTURE. — "Plainfield, N.Y., is noted for its picturesqueness, which is not in the least detracted from by the telegraph poles in the streets." We quote from a Transatlantic contemporary. It appears that this highly satisfactory result has been attained by causing the poles to be "finely finished and painted to represent trees." And so successfully has the illusion been carried out that we are assured that from a little distance a stranger would not recognise the true character of the vegetation.

AN UNSETTLED CLAIM.—The United States Military Telegraph Corps, a body which performed immense service to the Northern Army during the Civil War, has held an annual *réunion* ever since the war came to a close, although as a body it then ceased to exist. Its services have never yet been recognised by Congress, nor have the members received any honorary distinction. At the *réunion* which has just been held at Cleveland it was, however, stated that a Bill is now to be introduced which will render justice to the claims of the survivors.

ELECTRIC LIGHTING AND THE EYE. — When the electric light first became an accomplished fact, some fears were

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aroused as to the probable effect of the arc light upon eyesight. However, according to Dr. J. A. Andrews, who recently read a paper on the subject before the American Opthalmological Society, these fears are entirely groundless. As to the incandescent lamp, a very curious fact has been ascertained by Dr. Andrews—namely, that workers by this light who suffered from errors of refraction have found their sight to be materially improved by it.

Exhibition of Telephony.—In January next there will be opened at Brussels an International Exhibition of Telephony. The Exhibition will be held under the auspices of the Société Belge des Ingénieurs et Industries, and it is intended to arrange for a series of historical exhibits showing the progress of the art from its earliest infancy. There will also be a number of "conferences" on the various branches of the subject. On this occasion no charge will be made for space, and all expenses attendant upon the installation of exhibits will be defrayed by the committee.

The American Bell Telephone Company.—From some statistics recently published by this company we learn that the gross output of their instruments during the last six months was 27,961; but no less than 13,407 instruments were returned to the company, leaving a net increase in use of 14,554. During the same period last year 22,204 instruments were sent out, and 17,350 returned, showing an increase of only 4,854. The large number of instruments returned is attributed to the operation of the "Indiana Law" forbidding the maintenance of overhead wires.

The Amount of Light Produced from One Pound of Coal.—Recent tests at the Franklin Institute indicate that the amount of light produced by different methods from 1lb. of coal may now be taken upon an average as follows:—With naked arc lights, 150 candles (with shaded arc lights not more than 60 per cent. of the full light is usually obtained); with incandescent lights 20 candles, and with gas 14 to 17 candles. In this estimate steam coal is supposed to be burned under a good boiler for the electric lights, and the gas is supposed to be obtained from a bituminous coal.

The Henry Electric Railway.—At Kansas City what is claimed as a new system of electric railway has been devised by Mr. J. C. Henry. From the details to hand as to the method of gearing the motor shaft to the axles, and of regulating the speed of the motor, we are scarcely able to anticipate any very great success for this system. The arrangements are said to be "designed to be more or less automatic;" at any rate they succeed in being more or less wasteful of power, and considerably *more* rather than less complicated in comparison with any other system with which we are acquainted.

Wire Gauges.—The question of wire gauges has been under discussion in the United States for a long while past. At one time it seemed probable that the British standard gauge would be uniformly adopted by the American manufacturers. The *Electrical World* is, however, of opinion that quotations will ultimately be made only in thousandths of an inch. In that case we shall be enabled to retain our standard gauge all to ourselves, as there is little chance of its coming into use in France or Germany, where hundredths of a millimetre are almost invariably employed for the purpose.

A Heat-indicating Paint.—We have received from Mr. W. Crookes a sample of a heat-indicating paint. This paint is of a bright red colour when cold, but turns brown when subjected to a certain temperature, regaining its original colour on cooling. It is suggested that the paint will be of value for covering the bearings and other parts of machinery which are liable to injurious heating, so that an attendant may be able to see at a glance, without having to feel, whether any part is becoming hot and requires attention. It is stated that 1lb. of this paint is sufficient to cover 100 square feet.

"Lightning Holes."—On many of the summits of the High Alps, at elevations of 11,000ft. and upwards, certain curious cavities which occur in the rocks have received the name of "lightning holes." Sometimes detached masses of rock are found, having holes bored right through from side to side. Prof. Brun, who has been making a study of these phenomena, writes in the *Archives de Genève* confirming the opinion that they are due to lightning. He finds that the lining of the cavity has been completely vitrified by the passage of the lightning, and sometimes it has been scattered around the margin of the hole in the form of small pearly globules.

The Ohmart Lamp.—An arc lamp which has been devised by Dr. Ohmart is said to burn only 1in. of carbon per 100 hours. Some of these lamps are now in use at Boston; the size of the carbon or the candle-power of the lamp is not stated. The result is attained by enclosing the carbon, together with the mechanism of the lamp, in a sealed glass globe, and at the same time certain chemicals, which absorb carbon dioxide, are introduced—potassic hydrate, for instance. It follows that soon after the arc has been formed it is really burning in an atmosphere containing little else than pure nitrogen. The mechanism is designed to give a continuous feed, and it is said that the lamps may be left entirely without attention for weeks together.

The Carbon Industry.—The rapid and enormous extension of electric lighting in America has created a huge demand for arc light carbons. This industry is, on the other side of the Atlantic, almost entirely confined to the Cleveland district, where there are several very large factories belonging to the Wallace Carbon Company, the Boulton Carbon Company, the Brush Company, and the National Carbon Company. A few weeks ago the last-named company made a single sale of one million carbons. At Forest City a new company has recently started, which makes a speciality of cored carbons. Novel and ingenious machinery has been erected by which the manufacture proceeds with great rapidity. The company has already found it necessary to increase its plant.

The Lighting of Theatres.—Dr. Breslauer, of Berlin, has published an account of some observations which he has recently made upon the atmospheric condition of the same theatre when lit in the first place by gas and afterwards by electricity. The increase of temperature from the beginning to the end of the performance was in each case as follows:—In the pit 2·5°C. for electricty, 25°C. for gas; in the boxes 8·1°C. for electricity, 26°C. for gas. The heat is therefore more uniformly distributed with gas, though this is probably merely a local peculiarity depending upon the ventilating arrangements. The volume of carbonic acid per 1,000 parts was as follows:—In the pit 0·555 for electricity, 3·926 for gas; in the boxes 1·178 for electricity, 4·537 for gas.

Central Station Lighting at Berlin.—The number of lamps supplied by the Staedtische Electricitæt's Werke on the Edison system at Berlin is now about 8,000. The charge per lamp-hour of 16 candles is a fraction under ½d., but in addition to this the consumers pay a rental of 5s. 6d. to 7s. 6d. per lamp per annum, and a further charge of 31s. 6d. for the meter. The cost of installing the lamps and of making connection with the mains is also charged against the consumer. In the neighbourhood of the Frederichstrasse a central lighting station has quite recently been established by Messrs.

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Siemens and Halske. It is supplied by three *shunt-wound* machines, each for 500 lamps at 65 volts, and driven by separate engines. No further details have yet been made known.

A NEW SPECIES OF GRAPHITE.—M. G. A. Nussbaum is said to have produced a species of graphite whose specific resistance may be made upwards of a thousand times as great as that of the ordinary forms of hard carbon. At present the inventor modestly confines himself to the proposal to employ this material for regulating the amount of light given by glow lamps. This is not a direction in which any great distinction can be achieved. We would rather suggest that M. Nussbaum should turn his attention to obtaining the material in the form of "filaments." If the substance be sufficiently homogeneous it ought to be possible to make a 20 candle-power 100-volt lamp with a good stout ribbon-shaped "filament," which should work at a more economical rate and last longer than any lamp at present in the market.

THE CONDUCTIVITY OF WOOD.—Some experiments which have been tried recently as to the electric conductibility of various woods are of interest. The selected woods were of well-seasoned sound pieces, 3in. by $\frac{3}{4}$in. by $\frac{3}{4}$in. size, into which terminals 2in. apart were inserted, and the resistance of the samples taken between these points. The pieces of wood were kept for some time in a dry warm place to prevent surface conduction by moisture. The resistances obtained were mahogany 40 megohms, pine 214 megohms, rosewood 291, lignum vitæ 397, walnut 478, and teak 734 megohms. These results were obtained with the measuring current flowing with the grain, when taken across the grain the results were 50 to 100 per cent. greater. We believe that these experiments were undertaken on behalf of the United Telephone Company.

THE SUN LAMP AT ROME.—The principal railway station at Rome has been lit by sun lamps for some time past. It has, however, been decided to replace these by ordinary arcs. Difficulties arise with the sun lamp on account of the high temperature to which the whole body of the lamp is exposed. For this reason the cost of maintenance, together with the frequent renewals of the marble blocks, render the system much more expensive than that of open arcs. In addition to this, it is well known that the expenditure of energy per candle-power is very high in this type of lamp. If, however, the constructive difficulties could have been overcome the sun lamp ought certainly to have occupied a field of usefulness midway between the incandescent and the arc lights. But as matters stand, we fear that this, the most beautiful of the semi-incandescent type, is doomed to extinction.

THE THOMSON LIGHTNING ARRESTER.—When any of the numerous types of lightning protectors which are found (more or less) serviceable upon telegraph lines are adapted to arc light circuits, certain serious difficulties arise, for after a discharge has taken place through the protector the line will either be practically short circuited, or else the circuit is broken. To overcome this difficulty Prof. Thomson has introduced a pattern consisting of a V-shaped piece of metal, the two arms of the V being insulated from one another, but approaching within one-sixteenth of an inch. An electro-magnet connected in the line circuit is placed immediately below the fork, and the two arms are joined, one to earth and the other to line. Consequently, if an arc should be momentarily formed after the passage of a lightning discharge, it is repelled by the magnet, and sliding up the V is speedily extinguished.

ELECTRICAL SURGERY.—Upon the 8th August M. Albert Coindeau, while entertaining a select circle of admiring friends by inserting knives, forks, and sword-blades into his œsophagus, unhappily found himself unable to recover a valuable silver-plated fork. This implement measured 8$\frac{1}{2}$in. in length, and weighed over 2oz. Feeling annoyed at the loss, he applied to Dr. Polailler to assist in its recovery. With the aid of an electrical apparatus, designed for the purpose by M. Trouvé, the exact position of the fork was determined, and an incision being made, it was successfully extracted. Unhappily M. Coindeau did not himself survive. M. Trouvé's apparatus consisted of a slender probe, bearing two insulated points at its extremity. These were joined in circuit with a battery, and a not very sensitive galvanometer, so that the current passing was not sufficiently strong to give a deflection until the points touched the metal.

THE SUNDERLAND TELEPHONE EXCHANGE.—This exchange has recently been fitted with the American "multiple" switch-board, which enables a single operator to make connection between any two subscribers, however numerous may be the total number on the exchange. Besides Sunderland, the only towns in this country whose telephone exchanges are at present worked upon this principle are Liverpool and Glasgow. The practical advantages of such a system are very obvious. The system in general use requires the co-operation of two or more operators to make any connections beyond the limits of a single board which supplies some two or three hundred subscribers. The multiple switch-board, while sufficiently simple in working, is, however, a sowewhat complicated apparatus to fit up. At the Sunderland Exchange, where there are at present less than 300 subscribers, over seven miles of wire were used, and about 3,700 connections had to be made.

EARTH CURRENTS.—M. Lauderer has presented to the Academie des Sciénces a further note upon the subject of earth currents. M. Lauderer has a theory that the origin of earth currents may be traced to the action of winds upon the surface of sea and land. In this way he is able to some extent to account for the variable character of these currents, and hence for the rather puzzling fact of their independence of terrestrial magnetism. Monsoons and trade winds, and other more or less constantly directed wind currents, should upon this theory serve to determine constant earth currents in the localities where they blow. This verification of the theory has, however, yet to be obtained. On the other hand, M. Lauderer considers that the coincidence of sun spot maxima and minima with the extreme variations of earth currents tends to confirm his views, because the force of the trade winds is directly dependent upon the heat of the sun.

A MAMMOTH "BRUSH" DYNAMO.—The Cowles Electric Lighting Company are erecting very extensive works at Lockport, N.Y. They will be able to avail themselves of water-power at this place to the extent of at least 2,000 horse-power. The Brush Company are now building for them several dynamos of great size, which are to generate the current for the electric furnaces. The following figures give some of the details of one of these machines which has just been completed. This dynamo weighs altogether very nearly 10 tons; the weight of the armature is 1·92 ton. The total weight of copper used is 6,250lbs. The outside dimensions are 14ft. in length, 5ft. 2in. in height, and 4ft. 2in. in width. The machine is designed to absorb 355 horse-power, to run at 410 revolutions, and to give 3,000 amperes with 83 volts. The field-magnets are shunt-wound, and take a current of 80 amperes. The diameter of the pulley is 40in., and its face 45in. It will be driven by two 30in. Victor turbines.

PHOTOGRAPHY BY LIGHTNING.—Some good landscape photos have recently been taken in the United States by Mr. A. S. Barker by means of lightning flashes during a stormy night.

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A high wind was blowing at the time, and in one of the positives there are distinct traces of the leaves of the trees having moved during the exposure. The *American Meteorological Journal* is inclined to think that this may be accepted as good evidence that the duration of a flash of lightning is not in reality so short as is usually assumed. But, on the other hand, the *Electrical World* very properly points out that it is sufficient to suppose that more than one flash occurred during the exposure. If the flashes had succeeded each other at intervals of, say, one-tenth of a second, there would have been time for the leaves to move, but to the naked eye the flash would have appeared continuous. In any case the evidence is not sufficient to throw much doubt upon the conclusions drawn from Wheatstone's classical experiments, at least as to the order of magnitude to which the duration of the discharge is to be assigned.

THE NEWCASTLE EXHIBITION.—Our readers are already aware that an International and Colonial Exhibition on a large scale is to be held in Newcastle-upon-Tyne next summer. The site selected is a portion of the Town Moor, including the Bull Park. The annual show of the Royal Agricultural Society will be held on the Town Moor immediately adjoining the Exhibition. The building as at present planned will cover about 250,000 square feet. It will be built in the form of a rectangle, enclosing a garden of about three acres. One of the features of the Exhibition will be a model coal mine, illustrating the different methods of working which have been adopted. The whole Exhibition, including the mine and the garden, is to be lighted with the electric light A special committee has been made responsible for carrying this out, and circulars are being sent to the principal electric lighting companies and firms enclosing plan and sections of the building, and inviting them to state the terms on which they would be willing to light any portion of the building or grounds. We understand that the committee will be glad to send these invitations to any electricians who have not received them, and it is important that all proposals should be in the hands of the committee by the 28th inst. Applications should be addressed to "The Secretary, Exhibition, Newcastle-on-Tyne."

TELEPHONE RESTRICTIONS.—In the House of Commons on Tuesday last Sir H. Havelock-Allan asked the Secretary to the Treasury whether he was aware that the Post Office authorities had recently refused the Northern District Telephone Company permission to run wires for the purpose of telephonic communication over parts of the North-Eastern Railway Company's system, although the railway company was willing to allow the necessary posts and wires to be erected; whether he was aware that, in consequence of that refusal, the telephone company was unable to connect several of the principal firms in Hartlepool with the Telephone Exchange system, thus depriving those firms of the advantage which other traders in the district possessed of telephone communication with the Tyne and Tees districts, and with Sunderland; and whether, in view of the answer, he would state what course the Government proposed to take in the matter? Mr. Raikes replied that the Post Office has, subject to the concurrence of the railway company, granted permission, in some cases, to the Northern District Telephone Company to erect telegraphs on the North-Eastern Railway, and in some cases has refused it. He was not aware that several firms in Hartlepool had been deprived of telephonic communication.

THE PARIS EXHIBITION OF 1889.—The French Government has published a decree containing the regulations for the International Exhibition to be held in Paris in 1889. The following clauses will be of interest to our readers:—The Exhibition will be opened on May 5th, 1889, and will close on 31st October following. In the section devoted to each nation, the exhibits will be divided into nine principal groups, which will be subdivided amongst themselves into classes. The 6th group is devoted to "Apparatus and Processes of the Mechanical and Electrical Industries." Class 62 of this group contains the following subdivisions:—Production of electricity; electrostatic apparatus, batteries and accessories, dynamos and magneto-electric machines, accumulators; transmission of electricity; cables, wires, and accessories, lightning conductors, measurement of electricity, and apparatus connected therewith. Applications of electricity; telegraphy, signalling, telephones, microphones, photophones, electric light, electromotors, electric railways, transport and distribution of force, transformers, medical electricity; electro-chemistry; electro and permanent magnets; mariners' compasses; and electric clocks; various apparatus. No rent will be charged for space at this Exhibition, and motive power will be supplied gratuitously, provided that due notice of requirements be given.

THE LUGO LONG-DISTANCE TELEPHONE.—Mr. O. Lugo has devised an instrument, which is a combination of an ordinary magneto telephone, with a speaking condenser, similar to that originally constructed by Prof. Dolbear. Dolbear's telephone it will, however, be remembered consisted merely of two parallel and opposed plates, connected respectively to line and earth. The present instrument contains from 40 to 50 annular condenser plates, which are placed outside and surrounding the coil of the magnets. One pole of the condenser is connected with one end of the coil and to line, and the other pole to earth, the coil itself occupying the usual position in the circuit. Although we do not quite follow Mr. Lugo's explanation of the action of the condenser as given in the columns of the *Electrical World*, yet from the theoretical investigations which have been made in this country upon the effect of condensers connected with circuits traversed by harmonic currents, and containing self-induction, there can be no doubt that such a combination will have a tendency to assist in the preservation of tones which belong to the neighbourhood of some one particular rate of vibration or its octaves, but whether this action will be of much practical value is extremely doubtful. The volume of sound will also be somewhat reinforced by the articulations of the condenser itself, but this action has not very much to do with the length of line which can be spoken over, a loud-speaking telephone and a long distance telephone being by no means necessarily synonymous terms.

DYNAMO MACHINES AT THE ROYAL GUN FACTORY, ENFIELD. Captain Cardew, when testing three large dynamos recently supplied by Messrs. R. E. Crompton and Co., for the lighting of the new Nordenfelt Gun Department, adopted a novel but excellent plan of testing the efficiency. He took one dynamo and drove it as a generator, with the current from this machine he drove another as a motor, and from the mechanical power generated he drove a third machine as a generator. The electrical output of the third machine was measured by the same instruments as the electrical energy supplied to the motor, and was found to be 86 per cent. of it. If, therefore, the efficiency of these two machines was the same, as it is reasonable to suppose it would be, being identical in pattern, the motor yielded 92·5 per cent. of the electrical energy supplied to it as mechanical work, and the dynamo driven from it returned 92·5 per cent. of this again as electrical energy. This system of testing is absolutely beyond suspicion of error, as all the measurements taken are electrical, and the two tests of readings being taken by the same instru-

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ments, any errors of calibration or otherwise will cancel themselves, and in no way affect the result. All the machines were quite new, and were hardly worked under the best conditions; so that it is quite possible that their best efficiency approaches 94 per cent. It seems that this plan of testing, where three dynamos are at hand, is the most accurate one that can be adopted, and we think, with Capt. Cardew, that this system will be extensively used wherever the requisite number of machines are available.

SOME REMARKABLE EXPERIMENTS. — M. Henri Möhlenbruck, writing to *l'Electricien*, describes some very remarkable experiments which he has recently performed, and which seem to show that in the mesmeric condition an electric current may have a powerful inductive action upon the human nerves. The experiments were made with an apparatus consisting of a ring of iron wires, wound with silk-covered copper, the latter being placed in circuit with a microphone and a battery cell. The ring was about 9in. in diameter. In the first experiment a watch was placed near the microphone, and the ring was put upon the head of the mesmerised subject. He immediately began to beat time with the ticking of the watch. When the microphone contact was touched with a quill feather he placed his fingers in his ears. The microphone was then removed to a distant apartment, and the connection of the circuit being completed as before, a violin was played in the distant room; the patient showed the most distinct indications that he heard the music. The next experiment was obviously to speak to the microphone. "To my great surprise," says M. Möhlenbruck, "the patient repeated the words." The last experiment described is that of sending a continuous current through the circuit. This had the effect of causing the patient to throw his arms around in a circle in the vertical plane. The direction of motion was reversed with the reversal of the current. When the patient was asked what he felt like, he said he was turning. M. Möhlenbruck concludes his letter by stating that he has made a great many more experiments not less interesting than these, and has constructed many different kinds of apparatus to aid in these researches. He promises to give further details if they appear to be of scientific value. We await these revelations with breathless interest. It is clear, however, that the interests of the Bell Telephone Companies are greatly prejudiced by these researches. In future we shall be able to conduct telephonic communication with only a transmitter and a mesmerised boy.

THE PROJECTED CANADA-AUSTRALIA CABLE. — In the House of Commons this week, Mr. Stanhope, in answer to Sir S. Wilson, said the subject of telegraphic communication between this country and Australia had been brought under the notice of Her Majesty's Government by the Government of the Dominion of Canada, and it would receive careful consideration. The expense appeared to be great, and, until the opinion of the Australian colonies had been taken, the Government would not be able to form any judgment on the question. On the same subject we may give the following extract from a Wall-street journal merely for what it may be worth. Our own opinion is that so long as the scheme is put forward as a commercial enterprise, it has not the smallest chance of being carried out. A rough calculation of the probable outlay involved and a very liberal estimate of the probable traffic suffices to show the impossibility of a remunerative investment being found in this direction. The *Post* has a Montreal special devoted to Canada telegraph plans giving attention particularly to cable plans. Mr. John W. Mackay is represented to be interested in the proposition, and the Canadian Pacific engineer has prepared the following table of routes for the cables:—(1.) Brisbane or Sydney to North Cape, connecting at the former with the Australian Telegraph system, at the latter with the Telegraph system of New Zealand, 1,300 knots; (2.) North Cape to one of the Fiji Islands, 1,240; (3.) Fiji to Fanning Island, 2,270; (4.) Fanning Island to one of the Sandwich Islands, 1,200; (5.) Sandwich Island to Barclay Sound or Port San Juan, Vancouver Island, 2,730; (6.) Barclay Sound, across Vancouver Island and the Strait of Georgia to Vancouver City, the terminus of the Canadian Pacific Railway 100. Geographical miles 8,900. As soon as Mr. Fleming arrives from England a syndicate will be formed probably composed of J. M. Mackay, Hon. D. A. Smith, Sir George Stephen, and some New York and London capitalists, when the company will be launched forthwith. The Canadian Pacific Telegraph system will be opened to the public by the end of the month.

THE CHARGES FOR FOREIGN TELEGRAMS.—On Wednesday last in the House of Commons Sir G. Campbell asked the Postmaster-General why Great Britain charged for telegrams to be sent abroad a rate (1d. per word) much exceeding that charged by France and other countries, and double that charged in the United Kingdom; where the papers were to be found showing how and on what terms the Submarine Telegraph Company obtained a monopoly of the communications between this country and France; and on what terms that company was entrusted with the working of the Government lines to Holland and Germany.—Mr. Raikes, in reply, said that "not a few telegrams contain only three or four words, and the hon. member had not observed that, while a telegram of three words can be sent from England to France for 7½d., a telegram of the same length in this country costs 6d., and in France half a franc. Where there is a word rate pure and simple it is not unreasonable that the charge should be higher than where the word-rate is qualified by a minimum. At the same time I may say that the matters to which the hon. member draws attention are of considerable importance, and that they will form the subject of careful consideration when the relations between the Post Office and the Submarine Telegraph Company are reviewed prior to the termination of the subsisting agreement. The monopoly to which the hon. member refers was granted many years ago by the French Government, and I can only suggest that the papers may have been published in the official journal of that Government. The terms on which the Submarine Telegraph Company is entrusted with the working of the cables to Holland and Germany are stated in the agreement scheduled to the Telegraph Act of 1868. This agreement will be found in the appendix to the report of the Select Committee on the Bill. Fifteen firms connected with the Stock Exchange sent in a petition in February calling attention to delay and irregularity in the transmission of messages from the Continent, and expressing a hope that, when the monopoly of the Submarine Company terminated in 1888, the Post Office would make arrangements to improve the service. The complaint was general, and an answer was sent to the effect that the company did not admit that there was undue delay when the wires were in working order, but that if particulars of specific cases were furnished inquiry would be made. I would point out that the monopoly was not granted by this country, but by the French Government." The Postmaster-General was asked a similar question on Saturday last, and replied that no alteration could be made in the foreign telegrams tariff except at the International Telegraph Conference, which meets every five years.

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ON THE TREATMENT OF SECONDARY BATTERIES.*

BY BERNARD DRAKE AND J. MARSHALL GORHAM.

The possession of a reliable means of storing electrical power is now universally recognised. For electric lighting, whether temporary or permanent, whether domestic or public, it is almost an essential—for the commercial application of electricity to motive power it is a necessity. The theory of secondary batteries or accumulators, by means of which this storage is obtained, has already been so ably dealt with, and is, probably, so well known to all present, that it is unnecessary to enter into it in this short paper, the object of which is to bring to your notice some practical points of treatment which are essential in order to render secondary batteries commercially reliable.

These points have been arrived at by experiments carried on by Mr. Gorham and myself, in the course of the manufacture of the batteries of the Electrical Power Storage Company.

The three main difficulties which we had to encounter were—

1. The destruction of the lead grid or conductor.
2. The buckling or warping of the plates.
3. The falling out of the active material.

These three failings, principally affecting the peroxide plates, militated seriously against the commercial success of accumulators, of which durability forms so important a factor. We therefore carried out a large number of experiments, with a view to ascertain their various causes, and, by removing them, to render the secondary battery with which which we had to do as reliable for durability as it already was in other respects.

Here I may mention that these failings, although common, were by no means universal. For instance, the E.P.S. accumulators in the Bank of England have been in use for more than 2½ years, and continue to give excellent results. That they do so confirms the conclusions to which experiment has led us. We will take first :—

(1) The destruction of the lead grid or conductor. This was the most serious difficulty to face, as on it depended the life of the battery.

The prevalent idea was that it was due to overcharging; that after the peroxide plate was fully charged any further charge caused an evolution of oxygen which rapidly destroyed the grid. We therefore proceeded to charge some cells without cessation in order to ascertain the exact amount of current which would entirely destroy the lead conductor or grid. It was soon evident that the process was, at any rate, a slow one; but the experiment was continued, until the full prescribed current had been passed through, for more than two months. At the end of that time it was found that the lead conductor was practically as sound as before charging. The coating of fine peroxide formed on the surface was very thin; there was no sign whatever of buckling, and, further, the specific gravity of the solution, when the cells were left in their then fully charged condition, remained absolutely unaltered. The conclusion thence drawn was that the oxidisation of the grid caused by charging only penetrated to a very limited depth, and then ceased entirely, and that the coating of fine peroxide formed actually protected the grid not only from deterioration by overcharging, but also from local action, hitherto supposed to be unavoidable. It was then established that the life of the grids was not proportional to the amount of charging, *i.e.*, to the number of ampere hours *put into* a cell. Was it due to the number taken out? To ascertain this was the object of the next experiment.

For this purpose a battery was divided into two halves, one of which (A) was repeatedly run out, and the other (B) was never discharged beyond the point at which the E.M.F. commenced to drop. This experiment also extended over a considerable time, but gave the instructive result that when exactly the same number of ampere hours had been taken out of each half, the plates in the first half (A) showed signs of expansion or growing, whereas in those of the second half (B) no change could be detected. The life of the grid then was also not dependent on the *amount* of ampere hours taken out, or on the work done, but on the treatment of the plates, first as to charging up, and afterwards as to total or partial exhaustion. Further, it was satisfactorily proved that there was no necessity to employ a conductor of unoxidisable material, providing the simple precautions were taken—

1st. To fully charge the cells.

2nd. To avoid discharging them entirely.

The second point to be considered is :—

(2) The buckling of the plates.

This had hitherto been attributed to two or three causes—charging too rapidly; discharging too rapidly; impurities in the acid or oxides employed. Experiment soon showed that the real cause must be sought for elsewhere. We found that the buckling was almost invariably accompanied by a hard white enamel (sulphate of lead) on the face of the plates, and further, that where the extra cells in a battery had received more charging than the remainder, the plates in these cells were frequently quite free from sulphate, and the consequent tendency to buckle, while the rest of the battery had failed. This proved that the enamelling could be prevented by charging, and was not due to impurities in the oxides or acid used; further, that when the plates were free from sulphate there was no tendency to buckle. Experiment also showed that in the case of the first use of cells, when the acid was first put in, the specific gravity dropped in spite of the charging, indicating the formation of sulphate; by persevering in charging the sulphate disappeared, and with it the tendency to buckle. The conclusion was then that in order to avoid buckling of the peroxide plates, cells on their first use (whether new or after long disuse) should be charged incessantly until they are considerably over-charged. Hence the radical change in the instructions issued to users of the E.P.S. Batteries. Whereas hitherto they had been specially cautioned against overcharging, they are now urgently required to overcharge new cells and to charge incessantly.

(3) The separation of the active material. In almost every case where this occurred the plugs of active material fell out of the plates in complete halves and in a very hard condition; and analysis showed that they contained an excess of sulphate, due, as before explained, to insufficient charging. On the other hand, in a few instances the active material was found to have become disintegrated and fallen off in a fine powder, and this was specially observable when on account of a leak in the receiving vessel and consequent frequent addition of water, the solution had become extremely weak. In this case practically no sulphate was present, and the mass lost cohesiveness.

The conclusion is, then, that a certain proportion of sulphate in the material is necessary to bind together, but that excess must be avoided. This due proportion once ascertained the third difficulty is overcome for all the ordinary work of secondary batteries.

It should be mentioned, however, that there is a constant demand for an accumulator which can be discharged without injury at an abnormal rate for special purposes. Such rapid discharge results at present in the scaling off of the oxides and destruction of the plates, but as it causes the formation of sulphate, which is the binding not the disintegrating agent, the cause of the scaling, and, therefore, its remedy, must be sought elsewhere, and on this point discussion is invited.

I venture briefly to recapitulate the conclusions to which our experiments have led us.

1st. That the life of the leaden grids or conductors, and their freedom from buckling, are in no way dependent either on the amount of charging or discharging of the cells.

2nd. That cells on the occasion of their first use, and also after long intervals of idleness, should be very fully charged, and in the first case incessantly.

3rd. That they should never, under any circumstances, be entirely run out, and, in fact, should not be discharged below the point at which the E.M.F. begins to drop perceptibly.

4th. That the coating of fine peroxide formed during charging is actually a protection to the plate against the injurious effect of over-charging, and against local action.

5th. That a certain small proportion of sulphate is necessary to give cohesiveness to the active material, but an excess of it causes the oxide to separate bodily from the conductor.

* Paper read before the British Association at Birmingham.

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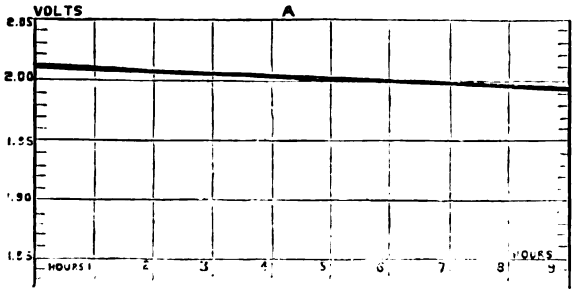
If the precautions here indicated be taken, we believe that the accumulators now made by the company with which we are connected will answer every ordinary commercial requirement during a very considerable time, but an accumulator is not at present known which, without sacrificing capacity and efficiency, will stand the extraordinary rate of discharge sometimes demanded. As we thought it might be of interest to give some reliable figures on the results which may be expected from cells as they are now made, we have, during the last few weeks, made very careful tests with some cells taken at random from stock and worked in accordance with the practical requirements of an electric light installation.

It will be seen from the curve marked A, which is the mean of six consecutive discharges, that the E.M.F. is practically constant during a discharge of such duration as the cells would ordinarily be called upon to give, namely, 9 hours, the fall of

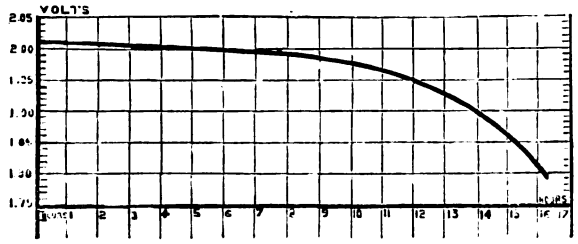


Curve A.

electromotive force during this period amounting to only ·02 of a volt. When the cells were discharged for 4½ hours, left standing for a day, and then discharged for another 4½ hours, the result was exactly the same as when the discharge was continuous, both as regards E.M.F. and efficiency. In fact, we were able to obtain a short time back from a similar cell, left fully charged for a month, an output of 380 ampere-hours.

The charging of the cells under test was always continued for about an hour after the gases commenced to be given off, so as to comply with the requirements of our working instructions, and to keep the plates in good order. This naturally reduced the efficiency or return both in ampere-hours and watt-hours; but in spite of this overcharging the result of six consecutive charges and discharges gave an efficiency of 90 per cent. ampere-hours and 80 per cent. watt-hours.

Curve B shows the capacity of the cells in ampere-hours when discharged at 25 amperes rate, and is the mean of two continuous discharges. It will be noticed that with 10 per

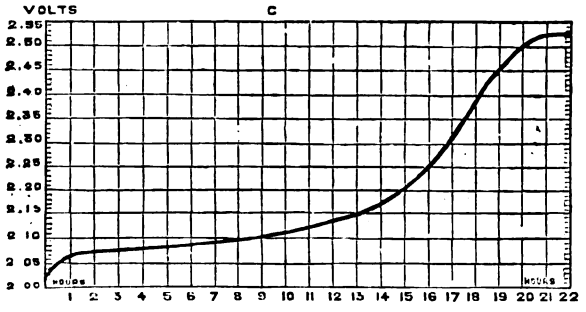


Curve B.

cent drop of E.M.F. the capacity is over 400 ampere-hours, and that the maximum output given in the lists of the company is reached with a drop of under 5 per cent. in E.M.F.

The curve marked C shows the rise of E.M.F. during the charge, the current being throughout kept constant at 22 amperes. It will be seen that at the commencement of the charge the E.M.F. required was only 2·02 volts, that after 220 ampere hours had been put in, representing about half the charge, the E.M.F. had risen to 2·13, and that when the cells were giving off gases freely the E.M.F. was as high as 2·53 volts. This curve will no doubt be of interest to those who manufacture dynamos for use with secondary batteries, as it shows clearly the range of E.M.F. for which provision has to be made if the current is to be kept constant. In most instances, however, we arrange for a maximum E.M.F. of 2·5 volts per cell to be charged, and allow the rate of charging to be diminished as the cells become full.

The cells tested were of the 15 L type, and contained 7 peroxide plates weighing 36lbs. in all, and 8 of spongy lead weighing 33½lbs. These plates are not made to give the maximum output from the minimum of weight, but the chief consideration is durability coupled with efficient working. They give a capacity of about 5 ampere-hours per lb. of plate, which in the S type plates is increased to 6½ ampere-hours per lb. for tramcar work; and where durability is of minor importance there is no difficulty in obtaining considerably higher results. The internal resistance of a single cell was measured during discharge, and found to vary from ·0012 ohm when the cells were fully charged, to ·0026 ohm when discharged, to 10 per cent. drop of E.M.F. This was tested by observation of the volts, first on open circuit and after-



Curve C.

wards discharging at a known rate, but owing to the tendency of the cells to rapidly recover their E.M.F. when left partially discharged, it is somewhat difficult to get reliable results after the E.M.F. has dropped to any extent.

We are convinced that the above figures are absolutely reliable, as the strictest precautions were observed by Mr. Butler, the head of our laboratory, in calibrating the instruments used and checking the results. The current was measured by frequent readings from a Siemens dynamometer, checked by a voltameter, the two being found to agree within 1 per cent. The E.M.F. was measured with a reflecting galvanometer calibrated by means of Clarke's standard cells and freshly made Daniel cell, the total resistance of the galvanometer circuit being 40,000 ohms.

PRIMARY BATTERIES.*

BY A. RÉNÉ UPWARD.

After briefly reviewing the forms of primary battery from the simple elementary cell to those of Daniell, Grove, Bunsen, &c., the author points out that the quantity of current given by the combustion of a given weight of zinc is the same in all batteries, but not the work done by the battery. The E.M.F. is proportional to the net gain of power in the chemical reactions.

The difficulties in the way of obtaining a perfect battery having been recapitulated, the author's battery, the chief characteristics of which are the use of free chlorine gas and the absence of polarisation in consequence of hydrogen not entering into the reactions, was described. The zinc being always in a solution of zinc chloride no local action occurs; there is no fear of mixing of liquids, as only one liquid is used. The further advantages of this form of cell are enumerated as follows:—

No fall in E.M.F., due to the solution becoming weaker, as the outer cells are always full of practically pure chlorine gas; no acids used in the cells (only pure water added); no liquids to remove; absence of smell or fumes; no amalgamation of the zincs; no destruction of the terminals; economy.

The chlorine generator and gasholders were described, as well as the chlorine cell itself, the battery, and the arrangements for the continuous automatic supply of gas to the cells.

Discussion.

Mr. Desmond FitzGerald said he would like to point out in connection with the sentence in Mr. Crawley's paper, reading "a gas instead

* Paper read before the British Association at Birmingham.

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of a liquid to act upon the zinc," that it was perfectly understood by all electro-chemists that if chlorine were brought into contact with zinc directly, whether or not there was carbon in the same electrolyte out of contact with the chlorine, the zinc was consumed entirely by local action without any possibility of obtaining a current. Therefore, it was altogether a mistaken idea to suppose that in the Upward battery the chlorine acted directly on the zinc. The ultimate result might be the same as if it did, but the principle to be followed in the construction of the battery undoubtedly was to bring the chlorine into contact with the carbon only, and as far as possible avoid any contact between the chlorine and zinc. To another statement made by his friend and old pupil, Mr. Crawley, he must demur, namely, that chloride of zinc solution had no action upon zinc. Chloride of zinc solution, as a matter of fact, had a very powerful action on zinc, a fact which all those who had had occasion to observe the extreme facility with which sub-chloride of zinc and the basic chloride of zinc were formed would be able to appreciate. In regard to Mr. Drake's paper, he could only compliment the E. P. S. Company on the energy and the measure of success with which they had overcome the inherent objection to their negative element, which was that it contained the elements of destruction within itself.

Prof. BLYTH said the storage cell was now so perfect that one felt that the attempt to construct primary batteries for electric lighting to compete with them had but little chance of success. He was very glad, however, to see so good a battery brought forward.

Prof. SILVANUS THOMPSON said he had made an experiment to test the statements current with reference to the chlorine battery. He took an ordinary cell of glass and placed it in two porous pots side by side. In one of these he placed a stick of zinc and in the other a plate of carbon, and the whole thing was filled up to a certain height with water, with a little chloride of zinc dissolved in it. He thus had a strong solution of chlorine and water. This produced absolutely no effect upon the E.M.F. when poured around the zinc, but raised the E.M.F. to the full value when poured around the carbon. He, therefore, concluded that the chlorine was an excellent depolariser, and that this was its function in the Upward battery. He looked upon Mr. Upward's battery as an extremely ingenious and possibly valuable way of making a constant Leclanché cell, by putting the manganese in a separate generator to evolve the chlorine separately, and then transferring the chemical action from the generator and distributing it through tubes to the respective cells. With respect to the formation of sulphate of lead in the battery which Mr. Drake's paper dealt with, it was pretty clear from the therma-chemical data, if anyone took the trouble to work out the thermal values of the connections, that the only chemical explanation that could be given of the battery was that the real electrolyte was sulphate of lead, and yet, in spite of that, if they got too much sulphate of lead in the battery, it became almost unworkable. He had made an inquiry into this, and the result he came to was that the sulphate which was disastrous in our batteries was not the ordinary sulphate of lead, but was the basic sulphate, for he had no difficulty at all in reducing, by protracted charging, the ordinary sulphate Pb SO_4 to spongy lead or to peroxide. But in the case of a battery that had been left partially discharged there was this same sulphate of lead in the presence of a partially deoxidised peroxide, giving rise to a reaction between the lower oxide and the sulphate, and to the formation of the irreducible basic sulphate Pb_2 SO_5. The latter was a hopelessly bad conductor. Mr. Drake said his figures, where the efficiency was expressed in ampere-hours, were 90 per cent., and the efficiency in watt-hours was 80 per cent. There was something curious about this, and he thought the whole thing wanted carefully defining, for he did not think so close an agreement as 80 or 90 per cent. was obtainable, seeing the difference between the E.M.F. and the internal resistance during charge and during discharge.

Mr. PREECE said that in practice the resistance of a secondary cell in discharging was very much less than it was in charging. There was a remarkable fact connected with secondary batteries that had not yet received the attention it deserved, namely, that not only was the resistance of a secondary battery cell when being discharged very much less than when it was being charged, but the resistance varied with the current of discharge. The larger the current of discharge the less the resistance, and the result was that a secondary battery was an automatic governor. In lighting up with the secondary batteries it had been thought that if the number of lamps was added to, some special contrivance would be needed to make the E.M.F. constant, but owing to this remarkable fact of the varying resistance, the E.M.F. remained practically constant. He could speak with experience of the use of the E.P.S. cells, for he had employed them for the purpose of lighting his house during the whole of the present year. The cells had been greatly improved of late, and they now left nothing to be desired. During the time he had used them he had never observed a flicker or had a disturbance or alteration of any kind, and he attributed that principally to the fact that he had implicitly obeyed the instructions given by the company. They did not receive the rough treatment which at one time the E.P.S. Company used themselves to give them. He had seen the company short-circuit a cell and raise a platinum strip a quarter of an inch thick to incandescence. They might anticipate, he thought, that secondary cells would last thoroughly for ten years or more. With regard to primary batteries, the function which the Upward battery was intended to fulfil was rather the function now performed by the gas engine than that of the primary battery. Mr. Upward used a secondary battery to light up a house, but the primary battery kept the secondary battery properly charged. Being in continuous use for 24 hours, the secondary cell was well charged when the time came to light up. He had during 30 years had something like 300,000 primary cells under observation, and, therefore, could speak of them from experience. He did not look upon primary batteries with any favour for electric lighting purposes. But the Upward battery had started quite a new feature, and was a very promising battery. He did not like the smell of chlorine, but when all difficulty with regard to leakage had been got over he thought there were a great many places (in the country particularly, where gas could not be produced) where this battery would come in very usefully for small installations. With regard to Prof. S. P. Thompson's remarks, the efficiency of a secondary cell was certainly 80 per cent. He had kept an accurate record of current that went into the battery, and the mean of current that came out of it, during the last twelve months, and he certainly got an efficiency out of his cells of 80 per cent.

Prof. SILVANUS THOMPSON said his remarks with reference to the internal resistance of the battery were more particularly in relation to what happened if the same current were used in charging and discharging.

Mr. HENRY LEA said he had used, since October or November last, 24 E.P.S. cells for lighting his house, and although the observations had not been taken continuously, as far as he could judge of the action generally of the batteries, Mr. Drake's statements had been borne out. The batteries should be well charged; no harm would be done by overcharging them, and as long as they were frequently overcharged they would preserve their good condition, as far as could be judged from the appearance of the plates.

Mr. R. E. B. CROMPTON said he regarded a good primary battery as a great desideratum, but he must concur with a previous speaker who pointed out that after all it was only proposed that the primary battery should take the place of the gas engine and dynamo, and must compare with that plant in facility of working and in cost. He was sorry to say that there was such competition in the manufacture of engines and machines that the cost of those parts of an installation was now so small that he did not think Mr. Upward could get below it. He could speak with experience on the subject of accumulators. He had employed them in central station lighting, and was carrying out a large experiment in making accumulators take the place of the gasometer in gas works, for he was convinced that that was the only way in which they could be properly employed in central station lighting. He had been working entirely with the view of getting a certain weight of lead and not a greater number of ampere-hours, and greater rapidity of discharge. He had already succeeded in getting a rapidity threefold greater than the company had obtained. Nothing greater than three amperes per square foot of peroxide plates had been mentioned, but he had got to 9 or 10 amperes without in the least damaging the cells. That was to say his cells ran down in one-third the time. He thought the reason of this was that the plates employed were comparatively homogeneous. They consisted of plates of lead cast in a particular manner, becoming porous in the act of casting, and subsequently sawn into thin plates, capable of giving a very heavy discharge indeed without any sign of distortion or any sign of flaking or of the active material being thrown to the bottom of the cell. He attributed the lack of flaking to the homogeneous nature of the plate. When the plate consisted of a grid pasted with a comparatively soft material, under the severe action of a heavy discharge there were distorting actions set up in the plate and a twisting or buckling of portions of the surface. That was perhaps a very crude way of explaining what took place, but he had watched it himself and knew that that was exactly what happened. But when a porous plate was employed consisting of a number of cellular things like a honeycomb, the whole of the interior of the surface being covered with an active material, this throwing down could not take place. The exterior surface was so small in extent that it did not matter. That was one way out of the difficulty of getting rapid discharge from accumulators. He could second what Mr. Preece had said as to the resistance of accumulators. A great portion of the work done in accumulators in the charging was done in the latter part of the charge. What appeared to be resistance mounted up very rapidly; that was probably due to bubbles of gas on the surface of the plate. As everybody wished to charge very fully, they continued to charge until bubbles were formed, and consequently a great deal of work was done on the plate which was never got back as useful work. He would not say that he had got absolutely 80 per cent. from his cells, but he had got very near to it.

Mr. SWAN asked whether, in the Upward battery, chlorine produced from hydrochloride of lime had been utilised. It was exceedingly cheap, costing only about £6 or £7 per ton, and it would seem to offer a means of getting chlorine in a very simple manner. After the nauseating repetition of very small changes in the form of primary batteries claiming to be inventions, even if only a change in the form of the vessel from square to round, it was quite refreshing to see some new departure. This battery of Mr. Upward was a new departure in the use of an excess depolariser almost automatically combined. The great difficulty seemed to him to be—and he admired the bravery with which that difficulty had been encountered—to prevent any escape of chlorine. Unfortunately the smallest escape of chlorine—and it seemed impossible to prevent a small escape—would be a quite fatal objection to its use with any comfort in the house, considering how pernicious chlorine was and how it corroded all kinds of metal.

Mr. G. K. WINTER spoke of the governing power of the battery in connection with its use for the lighting of trains. Although, of course, the secondary battery put on as a shunt on the dynamo was perfectly able to keep the E.M.F. from rising too high, provided the storage batteries had enough, yet in lighting trains it was of very great importance to get the storage batteries as small as possible, and find some other device to prevent the E.M.F. from rising too high for the safety of the lamps.

Mr. CRAWLEY, in reply to Mr. FitzGerald, said they were well aware of the fact that when Bl was in direct contact with Zn, there was a furious reaction, which was entirely local. But, in point of fact, there was *no* free chlorine whatever in the chlorine cell, for a weighed zinc plate hung up in a cell for days suffered no diminution of weight. Mr. FitzGerald also said that $Zn Cl_2$ *should* act on Zn and form sub-chlorides; perhaps

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it should, but in practice they did not find it do so appreciably. A piece of cleaned raw roof zinc was weighed and found to be 233·2 grains; it was then wrapped round with clean iron wire to promote local action, then placed in $Zn Cl_2$ solution taken from a working cell and left for days, at the end of which period it was unwound, well washed and wiped, and weighed 232·9 grains; loss, 0·3 grain. If this sub-action existed, therefore, it was so small as to be completely negligible. The theory which Mr. Fitzgerald had shown by means of the blackboard was that which they published some months ago in the pages of the *Electrical Review*, but which he (Mr. Crawley) omitted in reading the paper, as he had been particularly asked to be as brief as possible. In reply to Prof. Blyth, first, the battery did not compete with secondary batteries; on the contrary, for lighting purposes it was always worked in conjunction with them. 2nd. They had had a battery at work for nine months continuously. 3rd. The resistance of the porous pot did not vary at all; by using pots of proper porosity the zinc chloride solution was kept somewhere between 1·2 and 1·4 sp. gr.; there was no practical variation of resistance, as the specific resistance of $Zn Cl_2$ solution was between those rather wide limits practically constant. Prof. Thompson had spoken of Cl as the depolariser, which was, perhaps, natural at first sight. But a depolariser implied the existence of H, and as far as he had yet tried, nothing of the action in which H came in could give the E.M.F. which the cell did. On the other hand, the E.M.F. of the cell was practically identical with that due to the direct combination of Zn and Cl. The action took place electrolytically, certainly, and not directly; but if Prof. Thompson would look into the action he would find that, nevertheless, the final effect was that the E.M.F. was that due to the direct combination. Mr. Crompton said that the battery could never compete with the dynamo for cheapness. It would in any but what he would consider very small work never attempt to do so. But for such small work as must be done by batteries—and there was a great deal—it was the one which did its work with no waste of zinc, with the very cheapest possible chemicals, and the minimum of attention. In reply to Mr. Swan, they had worked with chloride of lime, but so far without very satisfactory results.

THE CENTRAL STATION AT ST. ETIENNE.

The Edison installation at St. Etienne, to which we have already briefly referred, presents several points of considerable interest, especially as the work has been carried out in the face of difficulties, in some respects of the same character as those which are likely to present themselves in this country. St. Etienne, as most of our readers are aware, is a large manufacturing town in the south-east of France. The district to be lighted lies in the centre of the town, where ground space is very valuable. It was therefore found necessary to place the machine room entirely outside the district, and at a distance of nearly 100 yards from the nearest lamps. This is, of course, a serious matter when a parallel system of distribution is adopted, and still more when, as in the present case, a simple two-main circuit is laid down. The installation is to be capable of supplying 3,000 lamps, for which 400 horse power will be provided; at present, however, only one half the total plant is required. The whole of the machinery, boilers, engines, dynamos, and subsidiary apparatus had to be placed in a building covering only 200 square metres of ground space, and in addition to this special precaution had to be taken to avoid any annoyance either from smoke, noise, or vibration to the houses on either side. The fact that these difficulties have been successfully grappled with undoubtedly reflects great credit upon the engineers, Messrs. V. Bietrix et Cie., by whom the arrangements were designed and carried out.

It was of course necessary to make the most of the vertical space. The boilers, four in number, were therefore fixed side by side in the basement. The four engines were placed on separate foundations built up between the boilers to a height of 18ft. from the basement. The engines are compound and non-condensing—water is dear at St. Etienne. They make 160 revolutions per minute, and at a pressure of 85lb. develop 70 to 75 horse-power. Under 155lb. of steam in the smaller cylinder the power is increased to 180 or 190 horse-power.

The cylinders, which are placed in tandem, are steam jacketed, and owing to the elevation of the engines above the boilers, the jackets are well drained and the water of condensation is returned to the boilers. The live steam is thus kept very dry. The consumption of fuel is said not to exceed 2·5lb. per horse-power per hour.

Each engine has a fly wheel on either side, and from one of these it drives by belting on to a countershaft, which runs the whole length of the room. This countershaft is placed, however, at a lower level than the floor of the engine room, so that it comes between the engines and the boilers. The dynamos are bolted to a substantial masonry foundation, which is built up from the basement to a height of 17ft. 4in. from the level of the boiler room. This masonry also serves to screen the heat and vibration from the party wall of the adjoining building. The lower part of it is also built into the brickwork of the furnaces, and forms part of the foundation of the chimney shaft, 150ft. in height. The dynamos are thus at a slightly lower level than the engines, but they are in the same apartment, and the belts by which they are driven from the countershaft come up through the vertical space thus exposed.

As all the engines drive on the same countershaft, any one or more of the engines and any one or more of the dynamos can be worked together. The eight pulleys upon the countershaft are provided with friction clutches, so that any required change can be made with great ease. The feed water is heated by means of the exhaust steam, and injectors are provided in case of accident to the feed pumps. The four boilers are all connected to one main steam pipe, so that any one or more can be employed with any one or more of the engines. The boilers are provided with electric apparatus to maintain the water level.

Turning next to the electrical arrangements, there is nothing particulaly noticeable in the Edison dynamos except that they are *not* of the improved Edison-Hopkinson type. They are each intended for 500 lamps of 16 candles and 110 volts. They are all normally connected to the same main collector, which conducts the current to the switch-board. An ammeter and a voltmeter are provided for each machine, and any of the feeders can be thrown in or out of circuit as may be required; the usual and well-known details of the Edison system are, in fact, carried out in their entirety, including the signal lamp connected through an earth circuit to give an idea of the insulation of the line. This remark applies, however, only to the indoor arrangements; out of doors the Edison conductors have been abandoned in favour of ordinary cables.

Considering the great good sense and judgment exhibited throughout this installation we are not surprised at this change. We have never been able to perceive any advantage in Edison's hemispherical conductors which could compensate for the large number and difficult character of the joints which are required. The method adopted for determining the dimensions and distribution of the conductors and feeders is noteworthy, and, though scarcely in accordance with the ideas of English electricians upon the subject, may yet prove serviceable with certain modifications (although we are not much inclined to think that a simple two main parallel distribution is ever likely to be undertaken in this country). In the first place it appears that the mains themselves, as distinguished from the feeders, were carried round the circuit just as required, and are apparently all of the same size throughout. It is then determined to allow a uniform fall of potential of 10 per cent. between the terminals of the machines and the extremity of the feeders. The problem is then considered to be reduced to that of determining the number, position, and dimensions of the feeders which will give this result—presumably under the condition of all the lamps being alight at the same time, as 10 per cent. is to be the *maximum* loss of potential. In order to determine these points a model of the district was prepared, and conductors were put in which represented the actual resistances of the circuit (including the lamps), both in position and in amount. By means of a battery arranged so as to have an E.M.F. of the same proportionate value, and connected to the proper points, the best size and position of the feeders were then determined experimentally. This empirical method is ingenious, and answers its purpose so far that it leads to a solution by means of which the required service can be maintained in the leads, but of course it cannot yield an economic solution. It seems to us that the proper way is to follow Thomson's law as far as possible, and only depart from it when, as is sometimes the case, it involves a variation in potential exceeding the required limits.

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THE ELECTRICIAN.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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THE POST OFFICE TELEGRAPHS.

Pressure on our space has compelled us to omit our usual review of the POSTMASTER GENERAL'S ANNUAL REPORT, which was issued at the commencement of the present month. Its interest and importance, however, demand some notice at our hands, even now. Lord WOLVERTON'S Report includes the first complete half-year of work under the revised tariff for telegrams, and we naturally turn to its pages to learn what has been the outcome of the financial experiment about which so much was predicted, for and against, in the autumn of last year. The scheme has now been in operation nearly a year; and, on the whole, we think its advocates have reasons to be satisfied with the result. They can at least show that the revenue is gradually improving on itself, and may, if it keeps on growing at the present rate, overtake the profit balance under the old tariff within a calculable number of years. On the other hand, its critics and opponents are afforded some grounds for their opposition by the accounts now published, which are brought down to the end of March of the present year. A loss of £40,233 is a sufficiently formidable sum for a Department which, during many years past, has uniformly boasted of being an earning and not a spending branch of the public service. Nevertheless, it may be urged that the penny post was introduced with a loss that was not made good till comparatively recent times; and those who think that the Post Office and the Telegraph are analogous businesses, are entitled to augur favourably from the history of the former.

In one respect the analogy is more close than it was a few years ago. Formerly it had to be pointed out that a telegraph wire is not a letter-bag, and that the cost of every telegram was a fixed sum, whereas, roughly speaking, the cost of despatching a bag of letters was the same whether the bag were full or half full, large or small. But the progress of electrical invention has done something at least to lessen this distinction. With the aid of multiplex telegraphy the capacity of the conductor has been immensely augmented; and the adaptation of the Wheatstone fast-speed system to multiplex lines has increased their powers in even greater proportion. To most of the great centres of industry telegrams are now sent, so to speak, in bundles, and their despatch approximates more and more to the transmission of carriers by pneumatic pressure, and letter-bags by railway. In this respect the electrical branch of the English Telegraph Department is ahead of every other telegraph service in Europe or the United States; and its limits of expansion in this direction have probably been well nigh reached, though the area of extension will of course enlarge with the development of traffic in districts that are at present adequately served with the ordinary appliances. The mistake which is made by the fanatics of cheap telegraphy is in supposing that any increase to the means of transmitting messages quickly and cheaply will everywhere be followed by a proportionate increase in their number. This has not been the case in countries where cheap telegraphy has long been the rule, and is not likely to be so here. A large addition to the number of telegram senders has doubtless resulted from the reduced charges; but the bulk of the increase lies with the regular class of customers who now send more telegrams because their cost is less.

The increase of messages under the reduced tariff has probably realised the highest expectations, the number being 16,787,540 in the last half of the year, against 11,314,423 under the old rate in the first half. Some error appears to have crept into the Report on page 9 in regard to the decrease of revenue, which is so stated that precisely the same difference is shown between the first and second halves of 1885-6, and the last halves of 1884-5 and 1885-6—a coincidence too extraordinary to be true. However, the loss on the year's receipts for the transmission of messages is what we have stated above, though fortunately the net revenue is not affected to nearly this extent. Some note is taken of the growth of business since the end of the financial year, and the figures are very remarkable. In April the number of messages was 40 per cent. over the number in April, 1885, and the receipts only £11,800 less. In May the increase was 51 per cent., while in June the percentage of increase had risen to 61, and the revenue was actually £2,800 in excess of the amount received in the corresponding month last year. Some further explanation would have been acceptable here; for without it we are unable to understand how an increase of 61 per cent. in the number of messages has more than balanced the lowering of their initial cost by 100 per cent. But probably the average payment per message exceeds the minimum charge in a higher ratio under the sixpenny tariff than it did under the shilling tariff.

One item of revenue is somewhat startling. No less than £18,214 was received during the year 1885-6 in fees for registered addresses. A hint is let fall that the abuse of this privilege may lead to its curtailment, and we are not surprised at it. On expensive lines, and lines of very limited capacity, where the saving of a few words is not only a boon to the sender, but is welcome also to the administration, the

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registration of abbreviated addresses is a perfectly legitimate arrangement. On inland lines with a popular tariff there is absolutely no justification for such a system at all. It is employed, to our own certain knowledge, as a means of advertisement, and is cheap at the price. But it is very dear to the Telegraph Departments, who are put to a vast deal of trouble for a very small payment, and who are deprived of a legitimate part of their revenue by a mere commercial subterfuge. The rule operates very harshly, too, on persons who are well enough known without their full address, but who now, as has recently been pointed out, "cannot be found," because their addresses have not been registered, there being other people of the same name in the vicinity. Thus the Department, while anxious to restrict the practice, virtually encourages the public in patronising it. When it is seen that a good deal of delay must arise from these abbreviated addresses, we may expect that many people will discontinue their fees. What will happen then? We confess we see no escape but by abolition of the system altogether in connection with inland telegrams. For the present the Report merely points out that "it would be much more to the advantage of the public to have their inland messages addressed in such a manner as would secure their immediate delivery without reference to records."

CORRESPONDENCE.

A SMALL ARC LAMP.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The progress of electric lighting some time ago created a field for arc lamps, of simple and compact construction and reasonable cost, which could work with a small current and in the same circuit with incandescent lamps, connected in parallel with each other.

For some time past I have made experiments with different kinds of such lamps, the most satisfactory coming under my notice being the Siemens and the one which I shall attempt to describe in the following lines.

Unfortunately, these lamps do not work without a resistance inserted in series with them. This circumstance not only involves a considerable loss of energy, but increases the first cost of the lamp; besides, as the resistance is considerable, it occupies so much space that it is not an easy matter to hide it away from sight.

The most satisfactory arrangement with respect to steadiness of light is as follows:—To obtain 65 volts as pressure on the mains, 40 volts pressure on lamp and a resistance of 8·3 ohms in series with the lamp, the current being 3 amperes, length of arc 1mm, and candle-power 150. We have thus—

Total energy used per lamp	$65 \times 3 = 195$	volt-amperes.
Energy lost in heating	$25 \times 3 = 75$	,,
Energy utilised in lighting	$40 \times 3 = 120$	,,

the loss being therefore about 38 per cent. I may here mention that the greater the current necessary for the lamp the less the loss in heating the requisite resistance becomes.

Thus, for instance, if the current is 6 amperes the pressure on lamp should be 44 volts, pressure on mains 60 volts, length of arc 2mm., and candle-power 300. Therefore,

Total energy used per lamp	$60 \times 6 = 360$	volt amperes.
Energy lost in heating	$16 \times 6 = 96$	,,
Energy utilised in lighting	$44 \times 6 = 264$	,,

the loss being therefore about 27 per cent.

If the current is 9 amperes, the pressure on lamp should be 48 volts, pressure on mains for a steady and reliable light need only be 58 volts, length of arc 3mm., candle-power 450. Therefore

Total energy used per lamp	$58 \times 9 = 522$	volt-amperes.
Energy lost in heating	$10 \times 9 = 90$	,,
Energy utilised in lighting	$48 \times 9 = 432$	,,

the loss being therefore 17 per cent. Now, in most cases this loss can be conveniently obtained if the branch leads are of iron instead of copper wire.

Thus, although most of the original difficulties encountered by designers and makers of such lamps have now been got over, this great difficulty of doing away with the resistance connected in series with each lamp, when several lamps are working in parallel with each other, has yet, I think, to be overcome.

The lamp I wish to describe is essentially electrical in its regulation. This is perhaps effectually settled by the strong necessities of cheapness and simplicity of construction. The principle of the lamp is that of a Gramme dynamo acting as a motor, and in determining the various proportions the following requirements must be attended to:—

Firstly, the armature should have two separate circuits of two distinct sorts of wire wound on it, the thick wire being in the main circuit, and the thin wire in the shunt circuit (in Fig. 1 the thick wire is represented by the shaded parts).

Secondly, there should be two separate and adjustable brush holders, one for each circuit (they are not represented in either of the figures), but there is room for the one above the armature and for the other below. They can be very conveniently fixed to the two pole pieces; the upper commutator is shown.

Thirdly, the ratios of currents and diameters in the thick and thin wire circuits on the armature must be such that when the arc is of normal length the polarities produced by the ampere turns of the two different circuits on the iron core of the armature should exactly balance, and the armature should remain stationary.

Lastly, the ampere turns of the main and shunt wire circuits wound on the magnet cores, should be more or less identical, and should be so connected up that the different circuits on one side produce one and the same pole, on the other side the opposite pole.

By calculation the following results are obtained for a lamp working with three amperes and 40 volts:—

(α) The shunt wire on the magnet cores. Per core—diameter 0·35mm., layers 47, turns 8,695, resistance 154·5 ohms, ampere turns 1,050.

(β) The main wire on the magnet cores. Per core—diameter 1·2mm, layers 4, turns 240, resistance 0·5 ohm, ampere turns 720.

(γ) The shunt wire on the armature core. Per division—diameter 0·25mm., layers 10, turns 250, resistance 6 ohms, ampere turns 12·5.

(δ) The main wire on the armature core. Per division—diameter 1·5, layers 2, turns 8, ampere turns 12.

And although the requirements are thus carefully attended to, it is advisable when regulating the lamp to the greatest nicety to try the effect of different shunts on the currents in the two different armature circuits. When the most sensitive arrangement is discovered, then the necessary shunt resistance can be introduced into the lamp in the form of a bobbin wound with german silver wire. When the polarity produced by the thick wire on the armature is stronger than the counter polarity produced by the thin wire, this occurs either when the carbons are together, or when the arc is less than of normal length. Then the armature revolves in that direction which raises the upper carbon; when the arc becomes too long, the armature revolves in the opposite direction, and should gently feed the upper carbon downwards.

Fig. 1 represents the upper portion of lamp in plan; the parts shown are armature, commutator, pole pieces, iron cores and bobbins of wire, respectively denoted by letters (a) (c) (p) (c) and (b). Fig. 2 represents the lower portion of lamp, and likewise the upper portion in elevation; the parts shown are the screw (s), which can be regarded as an elongated axis of the armature, the upper carbon holder (h), the lower carbon holder (h'), the lever (l) attached to the lower carbon holder for adjusting the lower carbon accurately opposite the upper carbon. This is effected by moving the lever (l) somewhat to one side, thereby releasing a screw and thus giving the carbon holder freedom for movement in any direction; the lower

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carbon holder is insulated from all the other parts of the lamp. The arrangement for lifting the upper carbon holder up and down the brass side tubes; this is effected by lifting the weight (*w*), by which movement the small comb (*x*), gearing into the screw (*s*), is pressed back, and the upper carbon holder can be moved up or down. An insulated copper wire descends the right hand tube, and is attached to the under carbon holder.

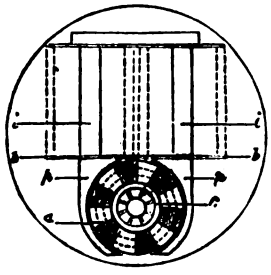

FIG. 1.

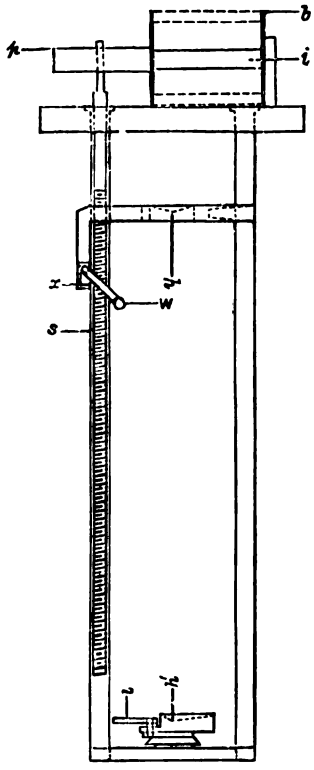

FIG. 2.

The carbons used are, above, a Siemens cored carbon, diameter 11mm., length 200mm.; below, a homogeneous carbon, diameter 6mm., length 200mm. These carbons burn with a current of 3 amperes, and an arc 1mm. in length for ten hours.

For the extra resistance which it is necessary to insert in series with the lamp, german silver wire of 1·2mm. diameter can be conveniently chosen; 10 meters of such wire make a spiral coil 20in. long 1in. diameter, and have a resistance of 1·7 ohm. The drawings are a quarter of natural size.—Yours, &c,

H. E. C.

LITHANODE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Without accepting the terminology mixed up with some parts of Mr. FitzGerald's article under the above dubious title, I cannot help feeling interested in the description of his experimental investigation of the subject. A brief recapitulation of my unwitting manufacture of "lithanode" nineteen years ago will perhaps strengthen rather than hinder Mr. FitzGerald in the pursuit of his experiments. In 1868 or 1869 Mr. Faure came to me with samples of his carbon bottle battery as a great improvement on Bunsen's. I bought some on trial, and found them about half as good as described, but still very good. I showed Mr. Faure the sulphate of lead battery I was using in large quantities, which, since the great practical improvement I had made in it, appeared to me to be perfectly satisfactory. I made a further slight improvement in it, and patented it in 1873, but the battery Mr. Faure saw was as follows:—In a three-pint stone jar, a cylinder of zinc presenting 60 square inches of surface on each side contained within it a porous jar, which again contained five thin sheet-tinned copper cups supported on a central wire. In the outer jar was put sea salt and water, and in the inner jar the cups were filled with sulphate of lead. The exact nature of its action could hardly be demonstrated until it had been in use some months. It then showed that in spite of the great weight of the lead sulphate, the whole of each mass was supported—raised—from the copper cup about a full sixteenth of an inch, resting on a layer of minute bubbles of hydrogen gas. The lead sulphate was in process of electrolytic conversion into peroxide, and in most cases it took about 18 months to convert the whole mass in each cup into a hard black lump. A primary battery could be thus serviceably utilised whilst producing the solid plates of "lithanode" described by Mr. FitzGerald. Instead of the half spherical cups, the lead sulphate should be contained in flat dishes, pressed down by weights of some inoxidisible material. After proving the trustworthiness of the battery above described in such important cases as the Grand Hotel at Scarborough, which, with over 340 bells in use, was in good order after 18 months, nothing but the small size and cleanliness of the Leclanché battery could induce me to give the latter the preference. Indeed, such experiments as Mr. FitzGerald's may cause a return to the lead battery as a primary battery.—Yours, &c.,

WALKER MOSELEY.

WINDING GALVANOMETER COILS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I should like to be informed by one of your numerous readers the way coils of astatic reflecting galvanometers are wound. Are they first wound on a skeleton frame, and solidified in paraffin wax, and then slipped into the boxes of the coil frame? A sketch of the tool used would simplify matters. On opening the coil (if hinged on frame) to look at the magnet, one sees no flange on the inner face of the coil, but the layers of wire are visible.—Yours, &c.,

London, Sept. 8, 1886. G. H. HEMECANS.

THE TELEPHONE SYSTEM.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am afraid the letter under the above title, signed "Telephone," is not likely to be backed up in the way that is necessary for immediate reform to be effected; but the attempt to rouse attention is natural and praiseworthy. I do not deny the *possibility* of reforming the telephone management in this country, for I have done more unlikely things myself; but there seems to be a peculiar paralysis affecting all telephone enterprise in Britain, and it is so little understood, and no single individual can afford to devote the requisite time to the work, otherwise the most obstinate, the most cunning, or the most imperious of telephone managers would have to succumb if the simple facts connected with British telephone exploitation were fully exposed. After being a year in the service of the United Telephone Company I had to draw up a report of things as I found them, and in self-defence I printed the report for the edification of the directorate. This was three years ago, and still that report would substantially apply to the present time. The criticism of "Telephone" is milk and honey compared to it. There is practically a deadlock in the development of one of the most useful inventions ever known. The remedy most likely to be effective promptly is to get a memorial from telephone subscribers, electricians, and others to the Board of Trade showing the justice and necessity for the present Patent Law to be made retrospective as regards the telephone. In the present law it is provided that if there be any reasonable evidence that an invention is not being supplied to the public in a satisfactory manner, the invention may be made by others, and a reasonable royalty awarded to the inventor or assignees after due investigation by the tribunal provided for in the said Act.

There would be nothing inconsistent or extraordinary in the proceedings I recommend. If the Board of Trade would not directly take the initiative in introducing a short Bill to meet the case, they would hardly refuse to facilitate the matter in other ways.

If the telephone invention is to be looked upon as an unconsidered trifle, then let it be held in the legal vice of private monopoly for four more years, when the patents lapse. The new birth will astonish the present "exchange subscribers."—Yours, &c.,

WALKER MOSELEY.

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ABSOLUTE NEGATIVE CHARGE.

TO THE EDITOR OF THE ELECTRICIAN.

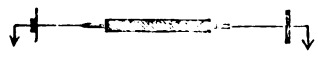
SIR: I beg to thank Mr. Williams for troubling to reply to my letter; but at the same time I must say that I cannot agree with all that his letter contains in support of the word electrostatics. No doubt it is convenient at times to make use of words and examples which only apply in part to the subject under consideration; still, it is advisable to dismiss them when they have performed that part, otherwise the part which did not apply might lead to confusion. Thus, electrical action is often explained by reference to hydraulics; if electrical action were to be compared to hydraulics in every case, I am afraid it would soon be found that "electricity into hydraulics won't go."

I apologise for again referring to a subject which perhaps only interests a few and bores a great many; for although a theory is necessary to understand a subject, yet practical application is of a more useful and enduring nature, and of greater interest to the general reader. With the advance of practical science many theories have been formed and many upset, while many more may be awaiting the same fate. I fear that if Mr. Williams's letter were to remain unanswered, I would appear to acquiesce in all it contains, and to abandon the views I expressed in my previous letter.

I agree with everything except that which relates to electrostatics. Unquestionably the word electrostatic was applicable to the double-fluid and single-fluid theories; when it was thought possible to have isolated charges of plus or minus electricities; to have an electric charge bound. But it seems that with the reasoning of the molecular theory the word static is out of place, the present explanation of the static circuit being so nearly akin to that of the dynamic. I fail to grasp the idea that leakage is an accidental action, but rather the natural action of electricity in completing its circuit, by distribution on substances in that circuit, in the inverse ratio of their conductive resistances.

I hope to be excused in giving the following illustrations to make my meaning appear clearer:—

In every text-book on electricity a list of substances is given, beginning with the best dielectric and ending with the best conductor. About half-way down the list we emerge from dielectrics into conductors. So we might expect that on a circuit consisting of dry ice and oil, static action would be manifest on one half of the circuit and dynamic on the other! Again, the action which takes place in a



circuit consisting of a battery, an insulated iron sheathed cable, and a condenser, the further plate of the condenser and one pole of the battery being put to earth, explained with the use of the word static, may prove, if it proves nothing else, that the words static and dynamic used in connection with electricity have a closer relation to each other than the explanation of the two words as given in a dictionary would warrant. Thus, talking of electricity in the form of a current, we would have dynamic electricity along the metal conductor, static on the condenser plate, static on the dielectric separating the two plates, and, I suppose, static and dynamic in turns on the further plate of the condenser. Whether static or dynamic electricity completes the circuit by returning to the negative pole of the battery I will not attempt to explain; perhaps a little of both. Of course, a similar action would be taking place between the conductor and the sheathing of the cable, but in a lesser degree, on account of the greater resistance, or lesser inductive capacity of the insulating material of the cable, compared with the dielectric in the condenser. Is it by accident that the electrical action takes place between the two plates of the condenser? I am afraid the telegraphing public would be rather alarmed if they were informed that their messages were transmitted merely by accident.—Yours, &c., LIONEL E. CAINE.

Villa Real, Algarve, Sept. 9, 1886.

INDUCTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Will anybody be kind enough to give me the following instructions? Is there a way to stop the induction or suppress it between telegraph and telephone wires, and how?—Yours, &c., AMATEUR.

THE "VOLTA."

The electric launch "Volta," which made the passage from Dover to Calais and back on Monday last, was built at Millwall by Messrs. Stevens and Smith, the electric fittings being designed throughout by Mr. Reckenzaun. The "Volta" is an undecked boat, 37ft. in length, 7ft. beam, and draws about 24in. when fully loaded. Underneath her deck floor she carries 61 accumulator cells, each containing 39 plates and weighing when filled about 72lb.; thus the total weight of the batteries was over two tons. The boat herself, with all other fittings, weighs five tons, and on Monday, with her passengers on board, the total weight could not have fallen far short of eight tons. The cells have a capacity of about 240 ampere-hours; the normal rate of discharge is about 28 amperes, which, at 120 volts, is equivalent to 4½ horse-power. Dividing 240 by 28 we get 8½ hours as the maximum period of discharge. The exact time occupied by the Channel voyage, both ways, was 8 hours 5 minutes, and during this period she covered at least 50 miles on the outward trip, the tide having carried her some considerable distance out of her straight course. The result thus shown cannot fail to be considered satisfactory, but at the same time it is fair to add that upon this occasion the weather was everything that could be desired, the sky cloudless, and "the narrow seas" as quiescent as by any chance they ever are.

Returning to technical details, the motors, two in number, are of the well-known Reckenzaun type, their armature shafts are mechanically coupled, and they drive the screw directly without intermediate gearing, an arrangement, which obviously offers great advantages in the way of simplicity of construction and absence of noise and vibration. All on board remarked the extreme smoothness of working, which, in this respect, is far superior to anything that can be attained by a steam launch. The screw is three-bladed, 20in. in diameter and 11in. pitch. Its normal speed is 600 revolutions per minute, and the type has been specially designed by Messrs. Stevens and Smith, after numerous experiments with various forms of screw-blades for running at a high velocity.

The motors are series-wound, the resistance of the field-magnets being 0·2 ohm and the armature 0·16 ohm, and they weigh about 4cwt. each. By means of a switch, which alters the electrical connections, three different speeds may be attained, of which the details above given refer to the slowest, the motors being then coupled in series. By coupling in parallel, which is effected by a single motion of the switch handle, the current is increased to 90 amperes, and the revolutions to 1,000 per minute, and about 14 horse-power is then developed. Of course, this rate cannot long be maintained, but it is extremely valuable in case of an emergency to be able to drive for a short time at high speed. Under these conditions the boat makes 12 or 14 knots an hour. The third speed is attained by sending the current through one motor alone; this gives 800 revolutions with 60 amperes. It may be noted that when working normally with the two motors connected in series the current through each section of the armature wire will be $\frac{28}{2} = 14$ amperes; when the two are worked in parallel the current will be $\frac{90}{4} = 22{\cdot}5$ amperes; but when a single motor is used the current increases to $\frac{60}{2} = 30$ amperes, more than double the normal armature current. The direction of rotation is reversed by reversing the current in the field-magnets, and without shifting the brushes, the latter having no lead in either direction. Under all circumstances the full number

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of cells are retained in circuit, so that the battery is always charged and discharged as a whole.

The voyage on Monday was effected almost without incident. We left the Admiralty Pier at 10:40 a.m., reached Calais at 2:32 p.m., started on the return journey at 3:14 p.m., and landed at Dover at 7:27. Although the return voyage occupied the longer time by about 20 minutes, yet the outward trip was actually longer by from two to three miles. The difference in time was mainly due to the slight breeze which in mid-Channel blew from the N.E. Soon after leaving Dover a gannet was seen floating on the water fast asleep. Before he quite realised his position one of the crew had him safely on board. It proved to be a very handsome bird, as large as a goose, and was brought ashore alive and unhurt.

The good people at Dover took much interest in our proceedings, and seemed to be under the impression that the "Volta" was intended to be placed upon the route to compete with the "Calais-Douvres."

As a matter of fact it may be well to add that the owners of the boat do not attach any exaggerated value to their enterprise from a scientific, or even from a technical point of view. At the same time they are undoubtedly entitled to congratulation on having made a highly successful demonstration of what can, under favourable circumstances, be accomplished by an electric launch, and all those who took part in the proceedings will retain pleasant recollections of the first occasion on which the Channel has been traversed by electric power.

WELDING BY ELECTRICITY.

A NEW APPLICATION.

Prof. Elihu Thomson, whose name is so well known in connection with the remarkable "Thomson-Houston" system of arc lighting, has recently given attention to the subject of welding by electric heat, and has attained results which bid fair to become of the highest practical importance. It is a well-known fact that it is a matter of the utmost difficulty to weld two pieces of metal together without leaving a more or less conspicuous bulge at the joint. In the case of wires it is quite impossible by ordinary methods of welding to avoid a considerable thickening.

Prof. Thomson has, however, found that if by suitable arrangements a powerful current be passed through the two ends of the wire while held in position, they unite together with a perfectly welded joint, which is nearly uniform in texture with the rest of the wire. This joint can be bent, twisted, hammered, and drawn without rupture.

Copper, brass, iron, steel, and German silver wires may not only be welded together by this process, but it is also easy to join German silver or brass to steel or iron, and doubtless other combinations will succeed when tried.

The manner in which the idea is put into practical operation is extremely simple, and will be readily understood by reference to the accompanying illustrations, Figs. 1 and 2, which we copy from the *Electrical World*. As will be seen, wires from an alternating source of electricity are led to a coil, P, wound round one side of an iron ring, F. A secondary coil, S, consisting of a few turns of heavy copper cable, is wound upon the same core. A resistance, R, is placed in circuit with the primary, so as to vary the strength of the current, and a switch, Z, permits of breaking the circuit at will. The ends of the secondary coil are attached each to one of a pair of copper blocks, L, L', which carry clamps for holding the wires in position, and for rapid manipulation they are hinged, as shown in Fig. 2. A nut, N, and a compressed spring permit the arms to be drawn together.

The wires being brought into contact by gentle pressure, the current is allowed to pass, the ends of the wires fuse, and, being pressed together, form a perfect welded joint.

Of course it is important that the wires shall be clean to insure good contact, and though usually the joint is well formed without any flux, such as borax, there is no objection to its use in slight amount in certain cases.

The advantages which this method presents over the usual manner of jointing must be evident. It enables the accomplishment in an easy manner of what was before very difficult or impracticable.

This method of welding is not confined to the electrical art alone, but promises to be of great benefit in the mechanic arts in general. By its means, chain links, rings, &c., can be easily welded, and the wires composing endless iron and steel cables can be joined without splicing, leaving the cable of uniform section throughout. Any wire can evidently be made practically of any length and without a perceptible joint. The invention also presents a great advantage in joining the ends of steel band saws, permitting the formation of joints without heating the metal to any considerable distance on each side of the joint, so that temper, elasticity and finish remain uninjured. Other applications will readily suggest themselves, and the invention must be looked upon as one of the most important of the recent applications of electricity.

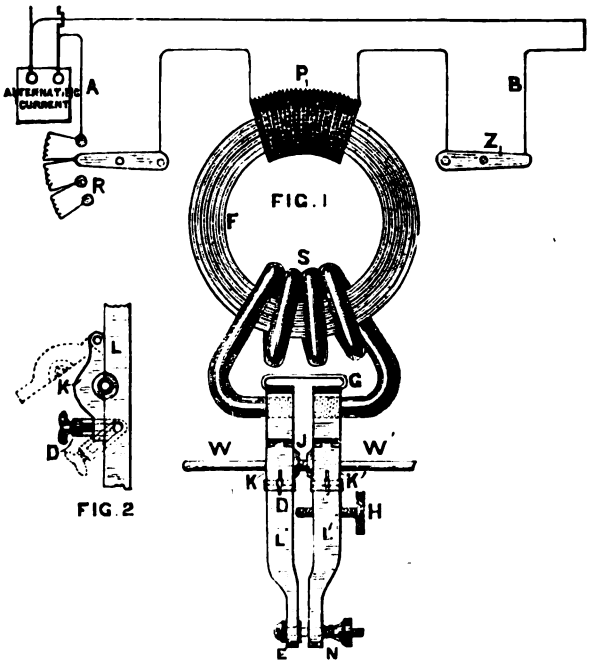

FIG. 1

FIG. 2

From the easy manner in which even heterogeneous metals are joined by this process, it would appear that the passage of the current in the presence of heat puts the metal in a peculiarly favourable condition, so that it welds easily. Hence Mr. Thomson proposes, in the case of large pieces, where the current alone would be insufficient to engender a welding heat, to heat the pieces additionally by external means, the presence of the current acting so as to make the weld more perfect.

A MERCURIAL AIR PUMP.*

BY JAS. T. BOTTOMLEY, M.A., F.R.S.E.

The primary object of the pump described in this paper is the removal of the mercury, which works the pump, from contact with the external atmosphere. When the Sprengel pump is used for producing and maintaining a nearly complete vacuum during a course of experimenting, which lasts over a good many days or weeks, it is found that the mercury running down through the pump and discharging into the open air, takes up minute quantities of air, which it carries with it in a state of very intimate mixture. This air intimately mixed with the mercury is not given up in passing through the air traps, but is deposited upon the walls of the pump head, and collects there into bubbles, which, though at first exceedingly minute, gradually increase to a sensible size. These bubbles ultimately escape from contact with the glass and deteriorate the vacuum.

The pump to be now described, as will be seen from the diagram, consists of a combination of a single-fall Sprengel with a Geisler pump; and, in addition, the moveable reservoir is furnished with an air-tight stopcock by means of which

* Paper read before the British Association at Birmingham.

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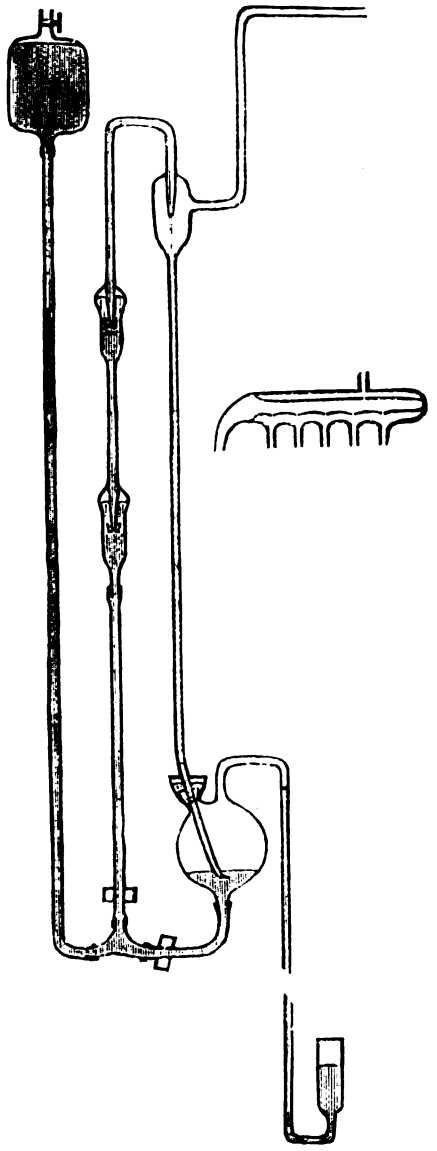
the air is got rid of from that reservoir and prevented from re-entering. In using the pump it is first worked as an ordinary Geisler pump till nearly all the air of the space to be exhausted has been removed. In this way advantage is taken of the comparatively great speed of the Geisler pump. When a good exhaustion has been obtained the stopcocks and the lift of the movable reservoir are so managed that the pump is thereafter used as a Sprengel, the small remaining traces of air being pumped by the Sprengel into the exhausted chamber of the Geisler; and when a sufficient quantity of air has been collected in this chamber, it can be removed by a single Geisler operation.



ON AN ELECTRIC MOTOR PHENOMENON.*

BY W. M. MORDEY.

About fifteen months ago, on the occasion of running and testing a Victoria electric motor in the works of the Anglo-American Brush Electric Light Corporation, an unexpected phenomenon was observed to the writer and his assistant, Mr. Watson. The motor was a 30 horse-power series-wound high-tension machine constructed to work with a current of 20 amperes. When the driving generator (a large Brush machine wound for 20 amperes) was started, the motor connected in the circuit also started, but ran slowly, and developed but little power. As there was apparently some fault in the connections, or elsewhere, it was necessary to examine the machine and circuit. In order to stop the motor, the circuit was broken by taking one of the leads out of the terminal to which it was connected. On doing this the motor, which at the time was running slowly in the usual direction, stopped suddenly, and instantly ran backwards—*i.e.*, in a direction reverse to that which was usual, at a rate of speed rather greater than its former forward rotation, slowly decreasing in speed until it stopped. It appeared at the first glance as if some connection still existed with the generator, but this was not the case, and it became evident that the machine contained within itself the cause of this behaviour. An examination of the circuit revealed the fact that the fields of the motor, instead of being joined in series with the armature, had, by mistake, been placed as a shunt across it. Otherwise, everything was in proper order. When the connections were put right, the motor ran without any unusual feature.

In considering the action to find the cause of the reversal, it will be seen in the first place that the slow speed at which the motor ran when connected with the generator was the result of the smallness of the current in the armature. The winding being intended for a series connection, the resistance of the fields was comparatively low, and when the armature and fields were connected in parallel, almost a normal field was produced, the armature receiving only a small portion of the current. To understand what took place when the circuit of the generator was opened it is only necessary to consider the case of any shunt motor. We know that when a motor is running its E.M.F. is, as it were, always trying to send a current in an opposite direction to that which is being forced through its armature. On cutting off the supply of current, this opposing E.M.F. is able to assert itself, and the motor becomes converted into a generator, the momentum of the armature and of any machinery that is being driven keeping up the motion for a short time, and causing the armature to generate a current, which circulates through the armature and fields. In fact, the shunt motor under such conditions acts like a series generator with its terminals short-circuited, the momentum of the armature and of any connected machinery being quickly exhausted, and the armature coming to rest. The intensity of this breaking action depends to some extent upon the form of the "characteristic" of the machine when working as a generator. Properly constructed shunt motors, having fields wound to a comparatively high resistance, do not show this action to any marked degree, unless a suitable external circuit is provided, because the high resistance of the field circuit prevents the generation of more than a small current; and shunt motors, which are incapable of acting as shunt generators, do not exhibit it at all. But most machines which are provided with shunt fields, the resistance of which is low, show it very clearly, and in a series machine on short circuit—that is to say, working merely through its own low resistance fields, as in this case—the action may be very strong, especially if the generating "characteristic" is not readily made to drop. Thus the armature is quickly brought to rest. But this does not explain why, when it had actually stopped, the armature started again in the opposite direction with a considerable velocity. This will be understood by referring to the figures. Fig. 1 shows the connections and the course of the current when the motor is supplied with the

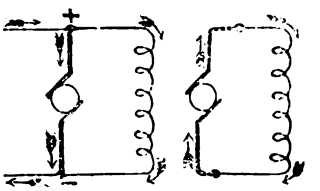


Fig. 1. Fig. 2.

current, and when it may be supposed to be running forward in obedience to the action of the current. Fig. 2 shows the direction of the current under the two conditions which successively occur when the external circuit is broken. In the first place, as already explained, on opening the external circuit, the momentum of the armature causes a current to be generated, which, it will be seen, flows through the armature in a direction opposite to that in Fig. 1,

* Paper read before the British Association at Birmingham.

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but in the same direction in the fields as before. This at once stops the armature unless the momentum is very great. Secondly, the momentary induced (extra) current follows in the same direction, at the moment when motion has ceased, and causes the armature to start again in the reverse direction.

This extra current is produced in both the armature and field magnet coils, but mainly in the latter, as the self-induction in them is comparatively great.

It may be of interest to add that the motor in question has for several months been working very successfully in New Zealand, where it is used to supply power to the machinery at the Phœnix Gold Mine. The current is generated by Brush dynamos driven by water power at a considerable distance from the mine, and is conducted to the motor by means of a copper wire the size of an ordinary telegraph wire (·165in. in diameter) supported on poles. The total length of the conductor is six miles.

This is a case of the installation, amongst the mountains of a remote colony, of apparatus by which 30 horse-power is being transmitted by a wire, of which five miles weigh less than a ton, with an effective useful return of over 65 cer cent., no skilled labour being supplied or required. There is nothing in this instance of transmission which scientific men can regard as novel, but it is an eminently practical one, and I may, perhaps, therefore, be permitted to draw attention to it in this place, because, although a great deal has been written as to the possibilities of the electrical transmission of power, there is still a scarcely-concealed scepticism on the subject.

It had been proposed to utilise the breaking power of motors by turning their momentum to account for the purpose of stopping them. I do not think this should be done. If power is to be wasted, by all means waste it in the brake block, or somewhere where it can do no harm, and not in a dynamo where excessive and sudden loads are very objectionable. Only in two cases would I recommend the use of motors as generator brakes. First, where a collision or accident of some kind could thereby be prevented, and, second, where the power generated could be utilised, and not simply wasted in heating the machine.

While speaking of electrical motors another point may be mentioned which is of some interest.

In Marcel Deprez's experiments in France failure seems to have been caused by the extra currents, induced on opening the circuit of the motor, breaking through the insulation, and special precautions have been taken to reduce the current very considerably before the circuit is opened. In motors this is less necessary than in generators. It is well known that if the armature circuit of a shunt generator is opened a very considerable arc may be formed by the continued generation of current at the moment of breaking the circuit and by the extra current. In series of generators a similar, but perhaps more severe, effect is produced, although if suitable care in construction is taken no breach of insulation need occur. I may mention that I have frequently opened the circuit of Brush generators, giving from 2,000 to 3,000 volts and 10 amperes by withdrawing one of the wires from its terminal, and I have never broken down a machine by doing so, although the arc which has followed the wire has been fully 12in. in length.

But what I wish to point out is the difference between the behaviour of a shunt generator and a shunt motor if the armature circuit is opened. In the case of the former, a very severe arc may be formed, as everybody knows who has lifted one of the brushes when such a machine was running. But in the latter case—that of a shunt motor—one of the brushes may be removed from the commutator with the formation of only a very small arc. It will readily be seen why this is so. In the motor armature there is an opposing E.M.F. very nearly equal to the supplying E.M.F., and consequently the extra current effect is greatly subdued, any extra current from the line passing through the field-magnet coils.

The problem of how to stop a motor without first stopping the generator seems to me, therefore, to be a very simple one, and undeserving of the very elaborate and ingenious devices which have been considered necessary in connection with the very interesting experiments already alluded to which have been going on for some years in France.

To stop the current at the generator possibly requires more care, and where the machine cannot be readily stopped the excitation of the fluids should perhaps be reduced before opening the armature circuit. The case of a series motor is rather different, but is not the same as a series generator, as it is practically only the extra current from the field-magnets which has to be considered.

DESCRIPTION OF EXPERIMENTS FOR DETERMINING THE ELECTRIC RESISTANCE OF METALS AT HIGH TEMPERATURES.*

BY J. T. BOTTOMLEY.

This paper gives an account of apparatus and experiments for the purpose of determining the electric resistance of certain platinum wires at temperatures varying from 0° C. up to a temperature of dull redness, or even a little higher. The wires experimented upon are wires which have been used and are in use in investigation of heat radiation at different temperatures in vacuums in air and other gases. The necessity for knowing with accuracy the rate of variation of electric resistance with temperature of the wires was explained in previous communications (1884-1885) to Section A of the British Association. The variation of electric resistance of platinum with temperature differs so much in different specimens that it is necessary to determine its value for each particular wire which is used in the investigation just referred to. The principal apparatus described are an air thermometer and a copper heating jacket, but a somewhat detailed account is also given of other heating apparatus employed and the electrical arrangements. The air thermometer used is shown in the diagram. It is formed from a piece of thin glass tube from $\frac{3}{8}$in. to $\frac{1}{4}$in. in internal diameter. This is allowed to fall in before the blow-pipe, and drawn out to a capillary tube at each end, and one of the ends A is conveniently turned up along the side of the bulb. The length of the bulb is from 2in. to 2$\frac{1}{2}$in. The thermometer is filled with perfectly dry pure air with the help of an aspirator, and the capillary tube A is closed by drawing off a small portion by means of a finely pointed blow-pipe flame, care being taken that the blow-pipe flame does not play on the open end, which might contaminate the air within. When a number of those bulbs are made and filled at one time, the end B is also closed after the filling with pure air, and the thermometers are then ready for use. When the thermometer is to be used it is placed in position, and very soon after the heating commences the end B of the capillary tube is opened with a file. When the bulb has taken the temperature which is to be measured a hand blow-pipe is brought and B is closed again. The thermometer having been removed from a hot space it is allowed to cool, is carefully cleaned if need be, and is then weighed. The weighing so obtained (after a small correction for air contained which it is often necessary to apply) gives the weight of the glass. The thermometer is then immersed in mercury or water which has been boiled and cooled (water is preferred by the author for reasons stated), and the extremity of the capillary tube is cut with a glass knife. The water entering fills the space with the exception of the air which was left in the thermometer at the high temperature. A second weighing is then taken. Lastly, the end B is opened and the thermometer is filled with water, and the third weighing is taken. The small portions of glass cut off are of course weighed with the thermometer, and care is taken as to drying the outside of the thermometer from weighings 2 and 3. A barometer is also read at the closing and at the opening of the thermometer, and the temperature of the water used is noted. Also the observed barometric pressure at opening is corrected from vapour pressure when

* Paper read before the British Association at Birmingham.

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water is used, care being taken to ensure as far as may be done that the air left in the thermometer is saturated with moisture, though the experiment is carried through with tolerable quickness to avoid loss of air by absorption in the water. Weighing number 1 being subtracted from weighing number 3 the whole volume of the thermometer (which must be corrected for expansion of the glass) is obtained. Weighing number 2 being subtracted from weighing number 3 the volume of air at high temperature is obtained. From the ratio of these two volumes the temperature is calculated by well-known formulæ. For temperatures below redness the thermometers are made of German or some hard English glass for higher temperatures of combustion tubing. A few words will suffice to describe the copper jacket. It consists of a considerable number [eight exhibited] of sheet copper cylinders, each having a bottom put one inside the other. These concentric cylinders fit each other very closely, there being only space for the lapping, with a few turns of the thinnest asbestos thread to hold them together and keep an air space of perhaps $\frac{1}{32}$nd of an inch. The internal diameter of the innermost cylinder is about 1in. A stopper of woven asbestos closes the open end of the innermost cylinder, and supports the air thermometer of the electrodes of thick copper, to which the platinum wire to be tested is attached by silver soldering. The platinum wire is in the form of a spiral, with turns well separated and wide enough in diameter to admit the bulb of the air thermometer. A very powerful Fletcher's solid flame burner gives ample heat to raise the whole copper cylinder and its contents to redness. Experiments described have shown that the temperature within the copper cylinder may be kept for any length of time so constant that there is no variation of electric resistance perceptible with exceedingly sensitive electric measuring apparatus. Temperatures lower than 300°C. have generally been detertermined with the aid of the vapour of liquids at high boiling points. A very convenient series of organic liquids was proposed by Doctors Ramsey and Young two years ago. The determination of the electric resistance of a wire was made by the potential method. An electric series is formed, consisting of a high gravity Daniel, the platinum coil to be tested, a known coil of platinoid on the inside of a large tin vessel filled with cold water (which contains a lump of slaked lime to prevent rusting of the vessel), lastly, a rheostat to regulate the series. Electrodes of a high resistance (10,000 ohms) galvanometer are clipped on alternately to the standard coil and the platinum wire under test.

THE BRITISH ASSOCIATION MEETING.

PRESIDENTIAL ADDRESS.

(Continued from page 370.)

This consideration opposes enormous physical difficulties to any theory of alternations of the oceanic and continental areas, except locally at their margins. I would, however, refer you for a more full discussion of these points to the address to be delivered to-morrow by the President of the Geological Section.

But the permanence of the Atlantic depression does not exclude the idea of successive submergences of the continental plateaus and marginal slopes, alternating with periods of elevation, when the ocean retreated from the continents and contracted its limits. In this respect the Atlantic of to-day is much smaller than it was in those times when it spread widely over the continental plains and slopes, and much larger than it has been in times of continental elevation. This leads us to the further consideration that, while the ocean-beds have been sinking, other areas have been better supported, and constitute the continental plateaus; and that it has been at or near the junctions of these sinking and rising areas that the thickest deposits of detritus, the most extensive foldings, and the greatest ejections of volcanic matter have occurred. There has thus been a permanence of the position of the continents and oceans throughout geological time, but with many oscillations of these areas, producing submergences and emergences of the land. In this way we can reconcile the vast vicissitudes of the continental areas in different geological periods with that continuity of development from north to south, and from the interiors to the margins, which is so marked a feature. We have for this reason to formulate another apparent geological paradox, namely, that while in one sense the continental and oceanic areas are permanent, in another they have been in continual movement. Nor does this view exclude extension of the continental borders or of chains of islands beyond their present limits, at certain periods; and indeed the general principle already stated, that subsidence of the ocean-bed has produced elevation of the land, implies in earlier periods a shallower ocean and many possibilities as to volcanic islands, and low continental margins creeping out into the sea; while it is also to be noted that there are, as already stated, bordering shelves, constituting shallows in the ocean, which at certain periods have emerged as land.

We are thus compelled to believe in the contemporaneous existence in all geological periods, except perhaps the earliest of them, of three distinct conditions of areas on the surface of the earth. (1) Oceanic areas of deep sea, which always continued to occupy in whole or in part the bed of the present ocean. (2) Continental plateaus and marginal shelves, existing as low flats or higher table-lands liable to periodical submergence and emergence. (3) Lines of plication and folding, more especially along the borders of the oceans, forming elevated portions of land, rarely altogether submerged and constantly affording the material of sedimentary accumulations, while they were also the seats of powerful volcanic ejections.

In the successive geological periods the continental plateaus when submerged, owing to their vast extent of warm and shallow sea, have been the great theatres of the development of marine life and of the deposition of organic limestones, and when elevated they have furnished the abodes of the noblest land faunas and floras. The mountain belts, especially in the north, have been the refuge and stronghold of land life in periods of submergence, and the deep ocean basins have been the perennial abodes of pelagic and abyssal creatures, and the refuge of multitudes of other marine animals and plants in times of continental elevation. These general facts are full of importance with reference to the question of the succession of formations and of life in the geological history of the earth.

So much time has been occupied with these general views that it would be impossible to trace the history of the Atlantic in detail through the ages of the Palæozoic, Mesozoic, and Tertiary. We may, however, shortly glance at the changes of the three kinds of surface already referred to. The bed of the ocean seems to have remained on the whole abyssal, but there were probably periods when those shallow reaches of the Atlantic which stretch across its most northern portion, and partly separate it from the Arctic basin, presented connecting coasts or continuous chains of islands sufficient to permit animals and plants to pass over.* At certain periods also there were not unlikely groups of volcanic islands, like the Azores, in the temperate or tropical Atlantic. More especially might this be the case in that early time when it was more like the present Pacific; and the line of the great volcanic belt of the Mediterranean, the mid-Atlantic banks, the Azores, and the West India Islands point to the possibility of such partial connections. These were stepping stones, so to speak, over which land organisms might cross, and some of these may be connected with the fabulous or prehistoric Atlantis.†

In the Cambrian and Ordovician periods the distinctions, already referred to, into continental plateaus, mountain ridges, and ocean depths were first developed, and we find already great masses of sediment accumulating on the seaward sides of the old Laurentian ridges and internal deposits thinning away from these ridges over the submerged continental areas, and presenting very dissimilar conditions of sedimentation. It would seem also that, as Hicks has argued for Europe, and Logan and Hall for America, this Cambrian age was one of slow subsidence of the land previously elevated, accompanied with or caused by thick deposits of detritus along the borders of the subsiding land, which was probably covered with the decomposing rock arising from long ages of sub-aerial waste.

In the coal-formation age, its characteristic swampy flats stretched in some places far into the shallower parts of the ocean.‡ In the Jurassic the American continent probably extended further to sea than at present. In the Wealden age there was much land to the west and north of Great Britain, and Prof. Bonney has directed attention to the evidence of the the existence of this land as far back as the Trias, while Mr. Starkie Gardiner has insisted on connecting links to the southward as evidenced by fossil plants. So late as the Post-Glacial, or early human period, large tracts now submerged formed portions of the continents. On the other hand the internal plains of America and Europe were often submerged. Such submergences are indicated by the great limestones of the Palæozoic, by the chalk and its representative beds in the Cretaceous, by the Nummulitic formation in the Eocene, and, lastly, by the great Pleistocene submergence, one of the most remarkable of all, one in which nearly the whole northern hemisphere participated, and which was probably separated from the present time by only a few thousands of years.§ These

* It would seem, from Geikie's description of the Faroe Islands that they may be a remnant of such connecting land, dating from the Cretaceous or Eocene period.

† Dr. Wilson has recently argued that the Atlantis of tradition was really America, and Mr. Hyde Clarke has associated this idea with the early dominance in Western Europe of the Iberian race, which Dawkins connects with the Neolithic and Bronze ages of archæology. Mr own attention has recently been directed, through specimens presented to the McGill College Museum, to the remarkable resemblances in cranial characters, wampum, and other particulars of the Guanches of the Canaries with aborigines of Eastern America—resemblances which cannot be accidental.

‡ I have shown the evidence of this in the remnants of Carboniferous districts once more extensive on the Atlantic coast of Nova Scotia and Cape Breton ("Arcadian Geology).

§ The recent surveys of the Falls of Niagara coincide with a great many evidences to which I have elsewhere referred in proving that the Pleistocene submergence of America and Europe came to an end not more than ten thousand years ago, and was itself not of very great duration. Thus in Pleistocene times the land must have been submerged and re-elevated in a very rapid manner.

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submergences and elevations were not always alike on the two sides of the Atlantic. The Salina period of the Silurian, for example, and the Jurassic, show continental elevation in America not shared by Europe. The great subsidences of the Cretaceous and the Eocene were proportionally deeper and wider on the eastern continent, and this and the direction of the land being from north to south cause more ancient forms of life to survive in America. These elevations and submergences of the plateaus alternated with the periods of mountain-making plication, which was going on at intervals at the close of the Eozoic, at the beginning of the Cambrian, at the close of the Siluro-Cambrian, in the Permian, and in Europe and Western America in the Tertiary. The series of changes, however, affecting all these areas was of a highly complex character, and embraces the whole physical history of the geological ages.

We may note here that the unconformities caused by these movements and by subsequent denudation constitute what Le Conte has called "lost intervals," one of the most important of which is supposed to have occurred at the end of the Eozoic. It is to be observed, however, that as every such movement is followed by a gradual subsidence, the seeming loss is caused merely by the overlapping of the successive beds deposited.

We may also note a fact which I have long ago insisted on,* the regular pulsations of the continental areas, giving us alternations in each great system of formations of deep sea and shallow water beds, so that the successive groups of formations may be divided into triplets of shallow water, deep water, and shallow water strata, alternating in each period.

But I must here call your attention to still another geological paradox, namely, that the deep sea, which is so great a barrier to the passage of the shallow water animals, seems, under certain conditions, to afford facilities for the transmission of land animals and plants. The connections established by the observations of the "Challenger," and so well expounded by Wallace and Hemsley,† between the floras of oceanic islands and the continents, establish this conclusively. Thus the Bermudas, altogether recent islands, have been stocked by the agency chiefly of the ocean currents and of birds, with nearly 150 species of continental plants, and the facts collected by Hemsley as to the present facilities of transmission, along with the evidence afforded by older oceanic islands which have been receiving animal and vegetable colonists for longer periods, go far to show that, time being given, the sea actually affords facilities for the migrations of the inhabitants of the land, greater than those of continuous continents.

In referring to the ocean basins we should bear in mind that there are three of these in the northern hemisphere—the Arctic, the Pacific, and the Atlantic. De Rance has ably summed up the known facts as to Arctic geology, and more recently Dr. G. M. Dawson has prepared for the Royal Society of Canada a *resumé* and map of what is known of the geology of the Arctic basin,‡ in comparison with Canadian geology. From this it appears that this area presents from without inwards a succession of older and newer formations from the Eozoic to the Tertiary, and that its extent must have been greater in former periods than at present, while it must have enjoyed a comparatively warm climate. The relations of its deposits and fossils are closer with those of the Atlantic than with those of the Pacific, as might be anticipated from its wider opening into the former. Blanford has recently remarked on the correspondence of the marginal deposits around the Pacific and Indian oceans,§ and Dr. Dawson informs me that this is equally marked in comparison with the west coast of America,‖ but these marginal areas have not yet gained much on the ocean. In the North Atlantic, on the other hand, there is a wide belt of comparatively modern rocks on both sides, more especially towards the south, and on the American side; but while there appears to be a perfect correspondence on both sides of the Atlantic, and around the Pacific respectively, there seems to be less parallelism between the deposits and forms of life of the two oceans as compared with each other, and less correspondence in forms of life, especially in modern times. Still in the earlier geological ages, as might have been anticipated from the imperfect development of the continents, the same forms of life characterise the whole ocean from Australia to Arctic America, and indicate a grand unity of Pacific and Atlantic life not equalled in later times,¶ and which speaks of contemporaneity rather than of what has been termed homotaxis.

We may pause here for a moment to notice some of the effects of Atlantic growth on modern geography. It has given us rugged and broken shores composed of old rocks in the north, and newer formations and softer features towards the south. It has given us marginal mountain ridges, and internal plateaus on both sides of the sea. It has produced certain curious and by no means accidental correspondences of the eastern and western sides. Thus the solid basis on which the British Islands stand may be compared with Newfoundland and Labrador, the English Channel with the Gulf of St. Lawrence, the Bay of Biscay with the Bay of Maine, Spain with the projection of the American land at Cape Hatteras, the Mediterranean with the Gulf of Mexico.

Thus far our discussion has been limited almost entirely to physical causes and effects. If we now turn to the life-history of the Atlantic, we are met at the threshold with the question of climate, not as a thing fixed and immutable, but as changing from age to age in harmony with geographical mutations, and producing long cosmic summers and winters of alternate warmth and refrigeration.

We can scarcely doubt that the close connection of the Atlantic and Arctic oceans is one factor in those remarkable vicissitudes of climate experienced by the former, and in which the Pacific area has also shared in connection with the Antarctic Sea. No geological facts are indeed at first sight more strange and inexplicable than the changes of climate in the Atlantic area, even in comparatively modern periods. We know that in the early Tertiary perpetual summer reigned as far north as the middle of Greenland, and that in the Pleistocene the arctic cold advanced, until an almost perennial winter prevailed, half way to the equator.

It will, I hope, meet with the approval of your veteran glaciologist, Dr. Crosskey, if I invite your attention chiefly to the old Lyellian doctrine of the modification of climate by geographical changes. Let us, at least, consider how much these are able to account for.*

The ocean is a greater equaliser of extremes of temperature. It does this by its great capacity for heat, and by its cooling and heating power when passing from the solid into the liquid and gaseous states, and the reverse. It also acts by its mobility, its currents serving to convey heat to great distances, or to cool the air by the movement of cold, icy waters. The land on the other hand cools or warms rapidly, and can transmit its influence to a distance only by the winds, and the influence so transmitted is rather in the nature of a disturbing than of an equalising cause. It follows that any change in the distribution of land and water must affect climate, more especially if it changes the character or course of the ocean currents.†

At the present time the North Atlantic presents some very peculiar, and in some respects exceptional, features, which are most instructive with reference to its past history. The great internal plateau of the American continent is new dry land; the passage across Central America between the Atlantic and Pacific is blocked; the Atlantic opens very widely to the north; the high mass of Greenland towers in its northern part. The effects are that the great equatorial current running across from Africa and embayed in the Gulf of Mexico, is thrown northward and eastward in the Gulf Stream, acting as a hot water apparatus to heat up to an exceptional degree the western coast of Europe. On the other hand, the cold Arctic current from the polar seas is thrown to the westward, and runs down from Greenland past the American shore.‡ The pilot chart for June of this year shows vast fields of drift ice on the western side of the Atlantic as far south as the latitude of 40deg. So far, therefore, the Glacial age in that part of the Atlantic still extends. Let us inquire into some of the details of these phenomena.

(To be continued.)

* "Arcadian Geology," 1865.

† "Continental and Island Life; Botany of the 'Challenger' Expedition."

‡ Meeting of May, 1886. The paper is not yet published.

§ A singular example is the recurrence in New Zealand of Triassic rocks and fossils of types corresponding to those of British Columbia. A curious modern analogy appears in the works of art of the Maoris with those of the Haida Indians of the Queen Charlotte Islands, and both are eminently Pacific in contradistinction to Atlantic.

‖ *Journal* of Geological Society, May, 1886. Blandford's statements respecting the mechanical deposits of the close of the Palæozoic in the Pacific area, whether these are glacial or not, would seem to show a correspondence with the Permean conglomerates and earth-movements of the Atlantic area; but since that time the Atlantic has enjoyed comparative repose. The Pacific also seems to have reproduced the conditions of the Carboniferous in the Cretaceous age, and seems to have been less affected by the great changes of the Pleistocene.

¶ Daintree and Etheridge, "Queensland Geology," *Journal* Geological Society, August, 1872; R. Etheridge, Junior, "Australian Fossils," *Trans. Phys. Soc.*, Edin., 1880.

ON ELECTROLYSIS.

BY PROF. OLIVER J. LODGE, D.SC.

(Continued from page 354.)

IV. Discussion of the Law (c) and Questions concerning Polarisation.

The chemical changes which go on in a circuit wholly electrolytic, or in any homogeneous portion of a circuit, are decomposition and identical recomposition, and consume no energy; accordingly no fresh E.M.F. is needed to send a current through a circuit wholly electrolytic or through a homogeneous electrolyte, *when the force is really applied to it* (*i.e.*, not merely applied to electrodes), and Ohm's law is possibly obeyed by electrolytes exactly as by metals. But at junctions of metals with electrolytes, or of electrolytes with one another,§ permanent chemical changes may

* The late Mr. Searles V. Wood, in an able summary of the possible causes of the succession of cold and warm climates in the northern hemisphere, enumerates no fewer than seven theories which have met with more or less acceptance. These are:—

1. The gradual cooling of the earth from a condition of original incandescence.
2. Changes in the obliquity of the ecliptic.
3. Changes in the position of the earth's axis of rotation.
4. The effect of the precession of the equinoxes along with changes of the eccentricity of the earth's orbit.
5. Variations in the amount of heat given off by the sun.
6. Differences in the temperature of portions of space passed through by the earth.
7. Differences in the distribution of land and water in connection with the flow of oceanic currents.

† Von Woeickoff has very strongly put these principles in a Review of Croll's recent book, "Climate and Cosmology; American Journal of Science," March, 1886.

‡ I may refer here to the admirable expositions of these effects by the late Dr. Carpenter, in his papers on the results of the explorations of the "Challenger."

§ Du Bois Raymond proved polarisation to be possible at liquid-liquid junctions. He also asserts the existence of "*innere Polarisation*" in a uniform liquid, which would be contradictory of what is said above; but

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occur, and at such places a finite E.M.F. must be situated; and the resultant of these may be negative, when it is called polarisation, or positive, when the whole arrangement is called a battery. Total polarisation may be regarded as the sum of two kinds:—

(*a*) Temporary polarisation, existing during continuance of current.

(*b*) Residual polarisation, existing afterwards.

Residual polarisation is caused by a more or less permanent alteration of the service of the electrodes by clinging or combined ions. Under this head comes the whole subject of secondary batteries.

Concerning temporary polarisation less is known.* On Helmholtz's theory it is caused by the deposited but unliberated and still charged ions being unwilling to part with their charges. Whenever the ions are able to combine with the electrode or with the liquid, and thus retain their charges, temporary polarisation is very small. It seems undoubtedly due to the same circumstances as cause the extra energy of the nascent condition of a substance; and it varies very much with the particular state of combination, or uncombination, into which the ions enter when set free from their former union.†

The above expression, in the form $\Sigma(J\epsilon\theta)$ or $\frac{\Sigma\theta''}{46,000}$, or $\frac{\Sigma\theta^{(n)}}{23,000n}$, may be used to calculate the theoretical E.M.F. of a battery cell formed of specified constituents in which known reactions go on.

Now is the law really true? Is E. really the E.M.F. needed to decompose a given substance? Or is it only a partial statement of a truth? It may at once be admitted that whatever *direct* thermal effects the current may produce, being an expenditure of energy in other than chemical directions, must lie outside the range of the above law, inasmuch as they falsify the assumption of (iv.) Irreversible or frictional heat, and likewise reversible or thermoelectric heat, must thus be considered separately. If ever the E.M.F. of a cell or a voltameter is seriously different from the value calculated on chemical ground it is to be examined whether there be not local heatings or coolings in the cell, whereby the E.M.F. may be either diminished or increased, being really the sum of two E.M.F.'s., a chemical one and a physical or thermoelectric one. But all this being understood and allowed for, as was really done by Thomson in his original paper in 1851, is the law sustained by experiment for cases other than the Daniell cell and a few other simple ones? For instance, when two substances combine and produce heat, is any of the heat a direct result of their union, or are electric currents the direct primary result and heat a secondary or derived result? If any of the heat be primarily generated, then it is to be surmised that this portion of the whole combination energy is electrically inactive, having no effect on either the positive E.M.F. of a battery or the negative E.M.F. of a voltameter. Secondary actions, for instance; it has long been a subject of debate whether the solution of zinc oxide in acid, or of zinc sulphate in water, contributed its full quota to the energy of the current and the E.M.F. of a cell, or whether the combination of zinc with oxygen was more intrinsically effective.

Joule showed how to attack the question for substances composing batteries, by immersing the battery in one calorimeter and its outer circuit in another. Whatever heat necessarily and intrinsically appears in the cell itself must be heat primarily and directly generated; but if all the heat of the battery can be made to appear in the outer circuit, by making the resistance of this circuit high enough, it is proof positive that the primary result of the chemical changes is electric current, not heat; and so in Joule's experiments with certain substances it appeared to be. More cells have since been tried, with the result that some directly heat, while others directly cool, themselves; though the bulk of their energy still seems to take primarily an electro-kinetic form. Helmholtz has discussed the whole question from the point of view of reversibility, *i.e.*, has applied the second law of thermodynamics as well as the first. Directly this mode of treatment is suggested it is almost obvious that a cell which heats or cools itself must have an E.M.F. variable with temperature, according to the law

$$Qd\mathrm{E} = -\mathrm{J}\frac{d\mathrm{T}}{\mathrm{T}}\mathrm{H},$$

where H is the reversible heat generated in the cell during the passage of a quantity Q of electricity, and $\frac{d\mathrm{E}}{dt}$ is the rate of change of E.M.F. per degree at the absolute temperature T.

Hence, to investigate the sum of the reversible heat coefficients for a whole cell, it is only necessary to experiment on the variability of its E.M.F. with temperature, and to write

$$\Sigma\Pi = \frac{\mathrm{H}}{\mathrm{Q}} = -\frac{\mathrm{T}}{\mathrm{J}}\frac{d\mathrm{E}}{dt}.$$

The properly calculated E.M.F. is then simply $\Sigma(J\epsilon\theta)$ but

$$\mathrm{E} = \Sigma\mathrm{J}(\epsilon\theta - \Pi).*$$

In a Daniell cell it happens that $d\mathrm{E}/dt$, and therefore $\Sigma\Pi$, is very nearly 0.

It is true that with voltameters a difficulty is often experienced, in reconciling the theoretical conclusion that a certain minimum E.M.F. is essential to the decomposition of a given substance, with the practical observation that any E.M.F., however small, can cause a constant leak through an electrolyte; but it has been pointed out, at sufficient length already, how all this is capable of easy explanation by means of secondary chemical reactions. For, remember that θ is the thermal value of the reaction which actually goes on. Now if the action is such as permits the ions to dissolve in the liquid, or to combine indirectly with each other, less energy is expended, and less E.M.F. therefore required, than if they were really set free. We must not take θ as measured for one kind of reaction and try to fit it to a case where an altogether different reaction is going on. Again, it may happen (especially with intense currents such as are most easily applied by the use of small electrodes like the ends of Wollaston wire) that ions are liberated in a condition of abnormal activity as, for instance, oxygen as ozone, antimony in its explosive condition, &c. This necessarily means greater expenditure of energy, in proportion to the thermal value of such extra activity, and accordingly a greater E.M.F. is needed to effect decomposition under these circumstances, *i.e.*, the polarisation E.M.F. rises in value, having been forced as high as 3·3 volts, in the case of dilute acid with platinum points, by Buff. If all these circumstances are properly taken into account, I am aware of no experimental reason which need cause us to doubt the general truth of the simple law, $\mathrm{E} = \mathrm{J}\epsilon\theta - \mathrm{J}\Pi$.*

V. Mechanism of Electrolytic Conduction.

Electrolytic conduction is, I suppose we may say certainly, a convection of electricity by the atoms of matter; but concerning the mode in which the atoms make their way through the fluid there are several hypotheses:—

(1) The molecular chain of Grotthus; modified and accepted by Faraday and many others, modified further by Hittorf to explain migration.

(2) The dissociation hypothesis of Clausius and Williamson; virtually accepted by Maxwell, modified by Quincke to explain migration, and shown by Kholrausch to explain the facts of conductivity.

(3) The electrostatic hypothesis of Helmholtz.

1. The Grotthus chain, with its postulated pairings and unpairings, is too familiar to need the smallest description. The only difference between the hypothesis as originally stated and the form in which I suppose Faraday to have held it, consists in whether the direct action of the electrodes be supposed to extend throughout the liquid, affecting and polarising every molecule in it,† or whether the electrodes' direct action be considered as limited to a very minute molecular range, all interchanges beyond this range being conducted on diffusion principles or by inter-actions among the fluid atoms themselves. The only objection that may plainly be urged against the theory is that it seems to require some small force able to effect the necessary initial decomposition, and it suggests that conductivity and tenacity of composition are related to one another in some opposing manner. Facts, however, fail to bear out any such idea; conductivity and chemical tenacity seem independent of one another; and, as has been just said under head "polarisation," no finite force, however small, has ever been found necessary to decompose an electrolyte when really applied to it. In other words, no polarisation exists inside a homogeneous electrolyte; *there is no chemical cling of the atoms there, but only a frictional rub.* Such a fact as this, if well established, renders necessary *some form* of dissociation hypothesis. A Grotthus chain of quite equidistant atoms might serve, or a momentary dissociation would be sufficient, but no hypothesis which involves a tearing asunder of molecules in the *interior* of a homogeneous electrolyte can be permitted. *Herein lies the great distinction between electrolytes and dielectrics.*

2. The form of dissociation hypothesis suggested by Clausius and Williamson is well known. It supposes that the vast majority of molecules in an electrolyte are quite insusceptible to the influence of electrodes, but that a few of them (the number being increased by complexity of composition and by rise of temperature) are, by collision or otherwise, dissociated, and exist in the free atomic state, each atom with its appropriate charge. These alone feel the influence of the electrodes. According to some statements of this hypothesis the direct influence of the electrode is supposed to reach every dissociated atom in the fluid; according to another

what he observed is plainly connected with capillary E.M.F. and endesmose, and in the light of these is natural enough.

* The experiments of Bernstein, as well as some by Beetz and Edlund, have shown how quickly it can rise and decay with make and break of current; so it is scarcely a valid proof of its complete non-existence when a galvanometer switched into a circuit is not deflected. At the same time no sharp distinction can be drawn between temporary and permanent polarisation, any more than between temporary and permanent magnetism.

† Mr. J. Larmer gave a short communication to the meeting, "On the molecular theory of galvanic polarisation," which he has expanded to a most interesting paper, and published in the *Phil. Mag.* for November, 1885. He shows that polarisation, whether natural or artificial, must necessarily diminish surface tension, without any question of exact reversibility; and he calculates the distance apart of the constituent molecules in the electrical layers of the voltameter condenser, whose capacity is becoming incipiently non-constant.

* The simple mode of writing the complete law is

$$\mathrm{E} = \mathrm{J}\epsilon\theta + \mathrm{T}\frac{d\mathrm{E}}{d\mathrm{T}}$$

From this it follows that if heat of combination is independent of temperature, $\frac{d\mathrm{E}}{dt}$ must be constant too; and generally, that

$$-\frac{d^2\mathrm{E}}{d\mathrm{T}^2} = \frac{d(\mathrm{J}\epsilon\theta)}{\mathrm{T}d\mathrm{T}}.$$

Another way of writing it is

$$\mathrm{E} = -\mathrm{T}\mathrm{J}\epsilon\int\frac{\theta d\mathrm{T}}{\mathrm{T}^2}.$$

Mr. Laurie (*Proc.* R.S.E., 1884-5) investigates the heat of combination of zinc and iodine by measuring the E and $d\mathrm{E}/dt$ of a zinc iodine cell.

† Grotthus in 1805 supposed electrodes to attract ions according to an elemental inverse square law.

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the direct electrode action extends only to those atoms which come within a minute range of its surface, everything else being managed by ordinary diffusion, *i.e.*, by the ordinary chance locomotions common to all atoms in a fluid. Individual atoms, though permitted to recombine as soon as they like, on this theory, are commonly thought of as existing in the dissociated state for a finite time. If there are chemical or other objections to such a view, it need not be held; all that the facts of electrolysis require is the most momentary dissolution of partnership, a temporary but quite perfect freedom, so that the feeblest possible influence may suffice to induce recombination in a definite direction, and with some atom other than its former partner. Provided a sufficient supply of such temporary severances occur throughout the liquid, no individual atom need remain in its uncombined state for a thousandth of a second, so far as the phenomena of electrolysis are concerned. But in proportion as the dissociated atoms are few and far between, the longer must they be supposed to continue in a free condition. Something must here be said concerning the views of Quincke and of Wiedemann on the mechanism of electrolytic conduction.

Theory of Quincke.—Prof. Quincke, adopting the dissociation view of isolated atoms, supposes the electrical charges of opposite ions to be not only opposite in sign but specifically unequal in quantity. He considers the direct action of the electrodes to reach every atom, and to propel the one set one way and the other set at a different speed the other way, according to simple electrostatic laws, and thus explains at one step both decomposition and "migration." Moreover, since the charges of opposite ions are not equal they do not neutralise each other; the resulting molecules are therefore charged with a balance of one or other electricity, and get propelled either with or against the current—thus accounting for electrical endosmose. Evidently the hypothesis is very elastic, and, if granted, explains the facts; but I must confess to an invincible repugnance to the idea of numerically unequal charges existing in the dissociated atoms of a molecule, as well as to the corresponding idea of all the molecules of an electrolyte being similarly charged.

The laws of Faraday seem to me to point so distinctly to a definite charge for every ion, depending solely on its valency in the compound from which it has just been liberated, that it would require very strong necessity to render palatable any other view. And I find no necessity at all. The inequality of charge is postulated only in order to account for the facts of migration as provisionally understood by Hittorf, *i.e.*, for the assumed inequality in pace of opposite ions. Now, without pressing unduly the prejudices I have ventured to suggest against such inequality in pace, I may claim to have proved that the facts of migration do not at any rate *necessitate* such inequality; and the facts of migration are all that the theory is based upon. And as to endosmose: it seems to me very doubtful whether any tendency to electric endosmose exists except in the immediate neighbourhood of a surface; one can only *observe* it in capillary tubes and porous partitions, and it seems allied to surface phenomena in general. It has indeed been elaborately considered by Helmholtz from this point of view, along with the reciprocal phenomenon of the E.M.F. generated by the flow of liquids along tubes.

Theory of Wiedemann.—Prof. Wiedemann's theory of electrolysis is not unlike Prof. Quincke's, but it is based on contact electricity. He supposes the atoms charged by contact with each other, and the molecule charged by contact with the vessel; and, having thus obtained the needful electrifications, decomposition and endosmose naturally follow; moreover, endosmose comes out properly connected with the existence of liquid and solid contact, or surface-action. But how does this theory explain migration? For the atoms in a molecule, if they electrify each other by contact, necessarily do so with equal quantities; and this is where the theory differs from Quincke's. Wiedemann explains the unequal rate of travel postulated by Hittorf, not by inequality in the propelling force, but (more satisfactorily as it seems to me) by a difference in the resistance met with. He would say that a hydrogen atom slips through the liquid more easily than an oxygen atom, and so gets along faster; moreover, he has conjectured, and experimentally verified within certain limits, that the ease of travelling of a given ion is inversely as the ordinary viscosity of the liquid: so that conductivity and viscosity are inverse to one another. He has further established the important and convenient fact that migration and endosmose are totally distinct things, having apparently no sort of relation to one another. Wiedemann's theory thus chimes in beautifully with that of Kohlrausch, who postulates a specific velocity for every ion; a velocity which depends only on the nature of the liquid in which it has to travel, and the $\frac{dV}{dx}$ which drives it.

That part of his theory which asserts a connection between conductivity and limpidity is curiously illustrated by the behaviour of water (or saline or acid solutions) at different temperatures flowing through a capillary tube. It is known that hot water flows some five times as fast as cold water through a given tube. It is also known that hot water conducts much better than cold. Further, it is known that if terminals connected to an electrometer are immersed in the liquid at either end of such a tube, an E.M.F. is discovered between them, depending on the rate of flow. Now, J. W. Clark has discovered that, notwithstanding its vastly greater rate of flow, the E.M.F. of hot water is almost identical with that of cold. His untimely death has prevented his publishing this result, but when he told it and showed it to me, some year or so ago, I conjectured that the observed E.M.F. must be a sort of residue of the whole generated E.M.F., being the part unable to leak back through the liquid; and I accordingly hunted up data to see whether the extra leakiness or conductivity of hot water might so nearly neutralise the E.M.F. generated by its more rapid flow as to give the same residue of E.M.F. Whether this be the true account of the matter or no, the fact is so. The empirical formula in Naumann giving the conductivity of the liquor used in Clark's experiment (it was salt and water, I think), at different temperatures contains practically the same coefficients as that giving the viscosity of the same liquid, measured by its flow through a capillary tube. The observation thus agrees perfectly with the theory of Wiedemann, connecting electrolytic conductivity with mechanical limpidity. The decrease in liquid viscosity with increase of temperature is remarkable. On any kinetic theory of viscosity, as due to diffusion, one would have expected it necessarily to increase with rising temperature. In a gas it does so, as is well known, but in a liquid it does just the reverse. I am unable to suggest any reason for this.

Circumstances affecting Conductivity.—There are two ways of increasing conductivity; increase of dissociation would seem to be the main cause when a weak solution is made stronger; diminished viscosity is probably the main cause when a cold solution is made hotter. But whether the remarkable change in viscosity caused by rising temperature is essentially the same thing as what appears in electrolysis to be extra dissociation I am not able to conjecture. Cases where the conductivity reaches a maximum at a certain stage of concentration, and afterwards diminishes as the strength of solution still further increases, are easily explained on Wiedemann's view of viscosity, combined with that of dissociation; for at first the percentage of dissociation may increase faster than does the viscosity, and so conduction be on the whole easier; while at last viscosity must increase fast enough to neutralise the advantage of whatever extra dissociation there may be. Indeed it is probable that dissociation itself may ultimately diminish, notably so for instance with nearly strong sulphuric acid, for it seems roughly to depend on heterogeneity of constitution. It may be plausibly argued that the experiments of Kohlrausch and Grotrian support the following view. Dissociation, and therefore also conductivity, falls to a minimum whenever the proportion of ingredients present are such as to make a very simple typical compound, such as (markedly) H_2O, or H_2SO_4, or even H_2SO_4, H_2O; but, with intermediate proportions, a certain number of semi-detached radicles are mixed along with these more stable compounds, and high conductivity is the result.

(To be continued.)

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Do. Preferred	54½,	55½	55½		54⅞	
Do. Deferred	10½,	11¼	—		—	
Brazilian Submarine	10⅞,	11	10¾		10⅝	
Cuba	11,	11½	11½		11 3-16	
Do. Preference	18,	19	—		—	
Direct Spanish	1½,	2	—		—	
Do. Preference	9,	10	—		—	
Direct United States Cable	8¾,	9¼	9		8¾	
Eastern Telegraph	1 ⅜,	11⅜	11⅜		11 7-16	
Do. 6 per Cent. Preference	14½,	15	14½		14 9-16	
Do. 5 per Cent. Debentures, 1899	105,	108	—		—	
Eastern Extension	12½,	12⅝	12 9-16		12 5-16	
German Union	9½,	9⅞	—		—	
Globe Telegraph and Trust	6⅜,	6⅝	6⅜		6 7-16	
Do. Preference	13½,	13¾	13½		13¾	
Great Northern	13½,	14	13½		12 5-16	
Indo-European	35,	36	—		—	
Reuter's	6½,	7¼	—		—	
Submarine	195,	205	203½		201	
West India and Panama	⅝,	¾	¾		—	
Do. 1st Preference	8⅞,	9¼	—		—	
Western Brazilian	6¼,	6⅝	—		—	
Western Union 7 per Cent. 1st Mortgage	118,	122	—		—	
Do. 6 per Cent. Sterling Bonds	101,	103	104		— x.d.	

TELEPHONES.

Consolid. Telephone and Maintenance	13 16	15-16	—		—	
Oriental	3-16	5-16	—		—	
United Telephone	14½,	14½	14½		13 15-16	

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	2½,	2⅝	2⅝		2⅜	
Do. (fully paid)	4½,	4⅝	4 13-16		3⅜	
Swan	⅜,	1½	—		—	
Maxim Weston	3-16	5-16	—		—	

MISCELLANEOUS.

Telegraph Construction	38⅛	39¼	39½		38¼	
India Rubber, Gutta Percha, and Telegraph Works	23½	24½	24½		23¼	

TRAFFIC RECEIPTS FOR AUGUST, 1886.

Companies.	August, 1886.	August, 1885.	Increase.	Decrease.
Cuba Submarine	2,200	2,262	—	62
Direct Spanish Telegraph	1,370	1,326	44	—
Eastern Extension	34,687	41,987	—	7,300
Eastern Telegraph	44,091	47,968	—	3,877
Great Northern	22,400	—	—	—
West Coast of America	3,105	—	—	—

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NOTES.

PATENT LAW IN NORWAY.—A new patent law is about to be promulgated in Norway.

THE WEST AFRICAN CABLE.—Telegraphic communication has now been established with Bonny, West Africa.

THE BIRKBECK INSTITUTION.—The sixty-fourth session of this institution will commence on Monday, the 4th of October.

TELEGRAPH CABLES REPAIRED. — The cables between Rangoon and Penang and between Madras and Penang are repaired.

THE "VOLTA."—The electric launch "Volta" left Dover on Monday for London, after her accumulators had been re-charged with electricity.

TELEGRAPH CABLES INTERRUPTED.—The cables between Jamaica and Colon and between Libertad and San Juan del Sur are interrupted.

SUBMARINE TELEGRAPH ACT (1885) AMENDMENT BILL.—On Tuesday last this Bill was read a third time in the House of Lords and passed.

FRANKFORT-ON-THE-MAINE.—The large railway station at this town is now lit by electricity. Power is obtained from the water mains, which were already provided for working the cranes and turn-tables.

CAST-IRON TELEGRAPH POLES.—We understand that a large order for cast-iron telegraph poles has just been placed with Messrs. Cochrane, Grove, and Co., North Ormesby, Middlesboro', by a Birmingham firm.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended the 15th inst. are £1,848, as compared with £2,051 in the corresponding period of 1885.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 17th inst. were £3,036, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

TUNGSTEN STEEL FOR MAGNETS.—M. Heppe states that the combination of tungsten with steel in the proportion of a one-hundredth part produces a steel capable of retaining its magnetisation unaltered for a much greater length of time than the ordinary qualities.

EGYPT.—Messrs. Crompton and Co. are supplying a No. 8 Crompton dynamo and 6 D D arc lamps, with about 100 incandescents, to Dr. Tweddle, for export to Egypt. We believe that Dr. Tweddle has carried out a large amount of engineering work for the Government in Egypt.

COBALT.—M. Berson, describing some experiments upon the influence of temperature upon magnetisation, in the *Annales de Chimie et de Physique*, states that the magnetic moment of a bar of cobalt *increases* continuously with the temperature up to 318°C., which is as far as the experiment has been carried.

IPSWICH.—The proprietor of the *East Anglian Daily Times*, Ipswich, who is building new offices and printing works, has decided to install the electric light, tenders for which will be opened next week. The lighting will consist of above 120 incandescent lamps, and three arcs of 2,000 candle-power each.

RENEWED EARTHQUAKE SHOCKS IN AMERICA.—Since the great earthquake which destroyed the city of Charleston upon the 31st August, shocks of minor severity have been continually experienced in Georgia and South Carolina. On the 21st inst. a shock of some violence occurred, which was felt as far north as Bridgeport, Connecticut.

THE SANDWICH ISLANDS.—It is stated that a representative of the Hawaiian Legislature, which has recently passed a Bill authorising the raising of a loan of 2,000,000dols. for public works, is now on his way to London to negotiate its issue. Among the objects for which the loan has been authorised is the laying of telegraph cables connecting the various islands.

SHIP LIGHTING.—Messrs. Dorman and Smith, of Manchester, have just completed an installation of 140 lamps on board the "Euterpe," a vessel which has been built at Sunderland for the Austro-Hungarian Lloyd's Steam Navigation Company of Trieste. The "Heraclides," a vessel recently launched at the same port, has been lighted with electricity by Mr. R. Miller, of Glasgow; this vessel is intended for the River Plate trade.

NEW BOOK.—We observe from the current number of the *Academy* that among forthcoming books is one by Messrs. Emile Garcke (of the Anglo-American Brush Corporation) and J. M. Fells on "Factory Accounts; their Principles and Practice, being a handbook for Manufacturer and Accountants." The book is to be published by Messrs. Crosby Lockwood and Co.

TELEGRAPHIC COMMUNICATION WITH AUSTRALIA.—In the House of Commons on Tuesday last, Sir H. Holland stated, in reply to a question, that during the last six years, upon only one occasion, namely, from the 7th to the 16th of the present month, has telegraphic communication between this country and Australia between dependent solely upon the line passing through Russia.

THE ELECTRIC LIGHT IN SPAIN.—*A Correction.*—Under this heading Mr. L. E. Caine writes to us from Algarve, Portugal, to the following effect:—"The letter in your number of the 10th inst. under the above heading necessitates a correction, which did not appear to me to require correction earlier. In sending the 'note' I omitted to mention that the town referred to is in Portugal."

THE LIGHTING OF THE PALAIS DE L'INDUSTRIE.—The French journals are making bitter complaints as to the working of this installation, which is said to compare very unfavourably with previous exhibitions of the electric light in Paris under similar circumstances. On the whole it is tolerably safe to congratulate ourselves upon the fact that electric lighting is not one of those things which they do better in France.

TRAIN LIGHTING.—On the Wurtemberg State Railway an attempt is being made to utilise electricity for train lighting. Storage cells are employed, charged by means of a dynamo which is driven from the axle of the guard's van. A very simple form of coupling has been devised for making the electrical connections between the carriages, and no trouble has hitherto been experienced in this matter, though only one train has yet been fitted up.

"NOTIONS ELÉMENTAIRES SUR L'ECLAIRAGE ELECTRIQUE." This is the title of a small pamphlet which we have received from M. Nelson Cherrill, electrical engineer of Lille, and which very clearly explains the principles of incandescent lighting, and the practical details to which attention should be chiefly directed in carrying out an isolated installation. The book is intended to give those not familiar with the science clear and simple ideas upon the subject of the electric light, and this it is well fitted to do.

THEATRE LIGHTING AT PARIS.—The lighting of the Palais Royal Theatre, to which we recently referred as being likely to be carried out by electricity, is now an accomplished fact. The total number of Edison lamps which are employed is 560. A compound engine of 35 horse-power, running at 300 revolutions, drives an Edison machine giving 450 amperes at 55 volts.

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Considerable difficulty was experienced in getting the machines into the confined space which was alone available. Nevertheless, to ensure safety the whole of the plant has been duplicated.

AN ARC LAMP INDICATOR.—Mr. Statter has devised a clock-work attachment for the purpose of "indicating" the feed of arc lamps. A pencil is attached to a convenient part of the positive holder, and the point makes a trace upon a paper which is folded round a cylinder. The clockwork causes the cylinder to rotate once in an hour, and in this way a complete record of the amount of each separate feed, the time at which it took place, and the total consumption of carbon is obtained. In *Industries* some curves obtained in this way for the Crompton, the Statter, and the Pilsen lamp appeared last week.

THE AMERICAN BELL TELEPHONE COMPANY.—The statistics recently issued by this company show that on 1st January, 1886, the number of telephone exchange systems in operation in the United States was 747, the number of offices open 1,175, number of circuits 112,067, number of miles of wire 114,046, number of *employés* 5,438, number of subscribers 137,750. Of the total number of exchanges no less than 512, or more than two-thirds of the entire number, were situated in towns having a population of less than 10,000. We cannot at present recall a single instance of a town of this size in our own country which is provided with a telephone exchange.

AN INCANDESCENT LAMP OF HIGH CANDLE-POWER.—At the recent meeting of the American National Electric Light Association at Detroit, a small exhibition for decided novelties was organised. Amongst the most interesting of these exhibits was an incandescent lamp of 400 candle-power, which is said to require only 425 watts. It is to be hoped that these statements will bear further investigation. A lamp fulfilling such conditions is certainly a desideratum. We do not understand that it is intended to claim an efficiency of the watt per candle for lamps of all sizes; this figure is in all probability only attainable in those of high candle-power, such as the one exhibited.

EDISON'S NEW CARBON FOR TELEPHONE TRANSMITTERS.—Edison has recently devised a modification of the carbon button in his telephone transmitter, which is said to greatly increase the efficacy of the instrument. He takes a textile or woven fabric, preferably that known as "veiling;" he forces lampblack or powdered carbon into the meshes under a strong pressure, and then carbonises it. Or, instead of this, he employs a disc of thin paper perforated with a large number of very fine holes, and treats it in the same way. It is evident that if this is a real improvement, it might with equal advantage be employed in the Blake transmitter, which is so largely used in this country.

TAUNTON PUBLIC LIGHTING.—A special meeting of the Town Council was held last week to consider the question of the lighting of the town. Tenders were received from Mr. H. G. Massingham, who has introduced the Thomson-Houston system into the town, as well as from the local gas company. The former offered to light two districts for £1,375, or for £725 each, the gas company tendering for the supply of gas at 3s 4d. per 1,000ft. It was estimated on this basis that the gas would involve an outlay of £1,200 a year, including another district not provided for in Mr. Massingham's tender. After some discussion the Lighting Committee was instructed to present a more exhaustive report.

SPIRAL LIGHTNING.—We recently recorded the fact that in some photographs of lightning flashes obtained in France the discharge has assumed a spiral, or, more strictly, an helicoidal form. M. Canastrini now states that in mountainous countries it is a well known fact that pine trees which have been struck by lightning are usually marked with an helicoidal furrow. He also quotes from a book published in 1867 (*Eclairs et Tonnerre*) by M. Fonvielle to show that the observation, though not new, is fully substantiated. It is even suggested that the fact was familiar to the ancients, for "the thunders of Jupiter" are frequently represented in spiral form.

SECONDARY GENERATORS AT THE PALAIS DE L'INDUSTRIE.—Messrs. Gaulard and Gibbs will shortly have an extensive installation of their secondary generators at work at the exhibition now being held in Paris. The *Bulletin Internationale de l'Etectricité* states that they have discovered in a corner of this exhibition an apparatus precisely similar in every respect to that of Messrs. Gaulard and Gibbs, which the inventor or constructor asserts to have been made long before the date of their patents. It would have been a remarkable exception to the established order of things if the priority of a *successful* electrical invention had been allowed to pass unchallenged, but it remains to be seen what value, if any, is to be attached to the statements of this particular claimant.

THE ELECTRIC LIGHT IN SPAIN.—The town of Gerona will shortly be illuminated throughout by the electric light. The motive power will be supplied by two turbines, situated about the centre of the town. The available water force is equal to about 90 horse-power, of which only 25 will be required. The installation will consist temporarily of 200 incandescent lamps, which will be lighted for 10 hours a night, and for each of which the town will have to pay 75 centimes. Besides these, 10 Gramme arc lights are already in use. These are fed by the secondary currents of four Zipernowsky transformers. The distributing circuits, which are of plain copper wire, are carried overhead upon wooden poles. In case of accidents to the turbines the dynamos will be worked by a steam engine, which is kept in reserve.

ELECTRO METALLURGY.—The large plating companies are at last waking up to the fact that the modern dynamo is far ahead of the machines of the older type that have been in use for many years for electro deposition. Messrs. Vivians, who are some of the largest copper workers in South Wales, have recently given orders to two or three of the best known electric light companies and firms for large dynamos to be used in their process. We understand that, among others, Messrs. Crompton and Co. supplied one of their "No. XL." machines, which gives 10 volts and 500 amperes. It is safe to say that within a very short time all the large companies engaged in the business of electric deposition will have discarded the old type of machines (which in some cases give no more than 40 per cent. efficiency) and adopted the more modern and efficient form of dynamos now to be obtained.

APPARATUS FOR RECORDING EARTH CURRENTS.—Prof. Shida, of the Imperial College of Engineering, Tokio, Japan, has devised a modification of the siphon recorder, by which the instrument may be employed to register the intensity, direction, and duration of earth currents. To the coil of the instrument, which moves under the influence of the currents, he attaches a light metallic arm; and by means of an ingenious arrangement of contacts, consisting of acidulated water maintained between a succession of insulating partitions arranged in a circle this arm is made to close one of a number of distinct circuits. The current in the circuits so closed causes a horizontal line to be traced upon a strip of prepared paper, after the manner of the Bain chemical telegraph. Each circuit when closed by the needle registers its own trace at a

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different height upon the strip. In this way a complete record of the earth current is obtained.

THE COMMERCIAL CABLE COMPANY.—The New York *Electrician and Electrical Engineer* says :—"If the Commercial Cable Company fails to achieve success, it will not be for lack of advertising. The *Herald* surrenders valuable space daily in both editorial and news departments to booming the enterprise. A quarter of a column in italics, kept standing on the editorial page, devoted to the details of a "race message" with the old companies, is a favour which no other company would be likely to obtain at any price. The other dailies, with certainly one exception, also give editorial endorsement to the Mackay-Bennett cable, and as the advertising of such companies is not freely indulged in when it must be paid for at regular rates, it is evident that it must be more than ordinarily effective." The English of this seems to be that the newspapers do the advertising in consideration of preferential advantages afforded them over this particular company's cables.

LIGHTNING AND LINEMEN.—It will be remembered that on Saturday, the 4th instant, a very heavy thunderstorm passed over the south-west of England, visiting Bridgenorth with great severity. It happened that at the time the Post Office was erecting near the town a new line of four wires to Wales. The men employed on the work were engaged in wiring, and two of them had a very narrow escape. One of the men was drumming out a wire, when it was struck by lightning, and the man was thrown violently on his back, the drum barrow being cast across the road. The other was running out the wire, and, having hold of it at the moment the lightning struck it, was also thrown upon the road and rendered speechless for a few minutes. Happily, neither of the men was seriously injured. This is only another illustration of the thoughtlessness of workmen in persisting in handling wires during a storm of thunder and lightning, which might easily result in much more serious consequences.

CHARTERHOUSE SCIENCE AND ART SCHOOL AND LITERARY INSTITUTE.—The winter session of this, one of the largest science and art schools in the United Kingdom, will commence on Saturday, October 2, 1886, under the presidency of the Rev. Henry Swann, M.A. During the late session about 850 students, mostly elementary teachers, availed themselves of the privileges afforded by this institution, and of this number upwards of 600 presented themselves from examination and were successful in obtaining a large number of first class certificates, as well as several honours certificates, from the Science and Art Department. Of the thirteen national scholarships granted by the Government three were carried off by London candidates, all of whom were students of this institution. Instruction of a practical character is given in most of the sciences, while the art school is under the direction of five competent instructors. There is also a well-fitted chemical laboratory, capable of accommodating sixty students.

AN ELECTRIC RAILWAY IN THE PYRENEES.—The electric railway, which is described in the following extract which we take from an article on the Lartigne single rail system of railway lines in the current number of *Engineering*, would appear to be one of the most interesting applications of electricity which has been heard of for some time :—"At the Ria Mines, Pyrénées Orientales, there is a very curious Lartigne railway, over which iron ore is carried for a distance of six and three-quarter miles. The line is worked by electricity, on a system designed by Messrs. Siemens, the full trains running down generating a current of electricity sufficiently powerful to haul the empty train up. The details of the system have not reached us, but we believe they consist in using the motor on the descending train as a dynamo, which generates sufficient current to work the motor on the ascending train, the difference between the weights of the two trains being enough to compensate for the loss of electrical efficiency."

A THERMO-ELECTRIC EXPERIMENT.—Prof. C. G. Knott, in the course of a paper on the electrical properties of hydrogenised palladium, which has been read before the Royal Society of Scotland, describes the following curious experiment :—Let a palladium wire be hydrogenised throughout one half its length. This is done by dipping one-half the wire into an electrolytic cell, and liberating hydrogen upon its surface. Attach the ends of the prepared wire to a galvanometer, and let a flame play gently upon the central point of the wire. A large current is at once obtained, which grows to a maximum, and then, as the temperature approaches a red heat, diminishes to zero, owing to the hydrogen having been expelled from this portion of the wire. If the flame be now shifted slightly towards the hydrogenised section the experiment may be repeated, and this may be done until the whole of the hydrogen has been driven from the wire, or until the gas has become equally distributed throughout its length. At the same meeting Mr. Thomas Andrews communicated a paper on the electro-chemical relations between metals and fused salts.

CAPITAL PUNISHMENT BY ELECTRICITY.—There is now being exhibited at Leipzig an apparatus for putting criminals to death by electricity. So long as it is found necessary to retain capital punishment upon our statute books it may well be that the electric method is the most merciful and least repulsive process that could be devised for carrying the sentence into effect. But if such means are ever adopted in this country the details will certainly not be carried out in the theatrical manner which commends itself to the Leipzig amateur. In this apparatus, behind the chair in which the condemned man is to take his seat—and by means of which, as we need not explain in detail, his body is placed in circuit with a powerful coil—there stands a conventional figure of Justice with bandaged eyes, holding the balance in her left hand and the sword in her right. The criminal having taken his seat, the proper functionary is supposed to read over the record of his crimes and the sentence of the law. This ceremony completed, he folds up the document and places it in the scale pan, the arm of the balance descends, closes the circuit, and all is over.

THE INSTITUTE OF MECHANICAL ENGINEERS.—The annual report of the Institute of Mechanical Engineers for the year 1885-6, which has just appeared, contains the usual list of subjects upon which the Council are willing to receive original communications during the ensuing twelve months. It may not be universally known that the Institute does not restrict the communication of papers upon these subjects to its own members alone, and in the distribution of the various premiums which are awarded for papers of substantial merit "no distinction is made between any person, whether native or a foreigner, whether belonging to the institution or not." There are five electrical subjects in the present list, which are classed as follows (the number given is that of the Institute list) :—41. Electromotors; their theory, practical construction, efficiency, and power. 42. The Construction and Maintenance of Secondary Batteries. 43. The Distribution of Electric Currents for the Electric Lighting of Towns. 44. Thermo-Electric Batteries, and their Application to Electro-Plating and other purposes. 45. The Application of Dynamo-Electric Machines to the Electro-Deposition of Metals from their Ores.

THE ST. LOUIS TELEPHONE CONVENTION.—A convention of the companies owning or working the Bell patents in the

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United States has just been held at St. Louis. The presidential address spoke very hopefully of the prospects of telephony in the immediate future, anticipating that the revival of trade, which seems at length to have become fully established in the States, will greatly stimulate telephonic activity. Elaborate statistics were quoted, which tended to show that up to the present time the average return upon capital invested in this direction has not exceeded 6 per cent. The address also contained a summary of the long roll of legal decisions by which the Bell patent has been upheld, and concluded with a facetious dialogue supposed to take place upon matters telephonic between President Cleveland and his private secretary, somewhat after the manner of Landor's "Imaginary Conversations." In this case, however, the necessary expletives were given in full. After several reports had been presented, Mr. Lockwood read a paper upon the employment of lightning protectors, expressing a preference for those which depend upon electro magnetic action over the fusible metal varieties. Several other papers of interest were to be read, notably, one on long-distance telephony, and one on cables and underground work, but the reports have not yet reached this country.

THE INDIAN TELEGRAPH SERVICE.—The *Indian Engineer* of 21st August has the following remarks upon the Indian Telegraph Service:—"The grievances of the Telegraph Department have elicited sympathy and support far and wide. They are a scandal to the State. The *Times of India* well observes that men of university education and scientific training were induced by the Secretary of State by certain promises to join the Telegraph Department. These promises have been shamefully broken. The least they had a right to expect was that their pay and prospects would be equal to those of men appointed to the Forest Department. They are far inferior. A man having entered the Telegraph Department by competition, finds after twelve or fifteen years' service that his pay and prospects are even inferior to those of lads who have without examination been appointed by local Governments to the salt or police. An anomaly and iniquity of this nature ought not to be allowed to exist. It ought not to be allowed to exist on economic grounds, for the most useless and expensive article that a State can possess is a discontented public servant, and the members of the Telegraph Department would not be human if they were not thoroughly discontented."

FURTHER TELEPHONIC SQUABBLES IN THE STATES.—The New York *Electrical World* says:—"A despatch from Washington announces that a bill in equity has been filed in the District Supreme Court by C. G. Beryman for Henry C. Strong, of Chicago, against Robert B. Vance, Acting Commissioner of Patents, and Elisha Gray, for an injunction to restrain the issuing of a patent to the latter. The complainant states that he is the inventor of the railway electric telegraph and telephone, and applied for a patent May 18, 1877; that this application has been kept alive by amendment to claims, &c., that Gray subsequently filed an application for a patent for 'multiple telegraph,' which, he alleges, was by trickery and deceit stolen from him, and is nothing but a reproduction in principle and design of his machine and invention. He charges that by undue influence and by complicity with the examiners, Gray is about to receive a patent; that the issuing of a patent to complainant is delayed by Gray's influence, and the patent to Gray is about to be issued by fraud and collusion with the officers of the Patent Office, and if so issued, will greatly injure and delay him, and necessitate long and tedious litigation on his part. He further alleges that he is entitled to official action on his claim, and asks an injunction and relief. Judge Hagner set the first Monday in September, at 12 o'clock, for a hearing."

"THE JUDICIAL WARPING OF PATENTS."—*The Times* of Sept. 22nd contains a further letter upon this subject from Prof. S. P. Thompson, of which the following is the concluding paragraph:—"To sum up the whole question I have pointed out that there exists a practice of judicially stretching patents so as to make them include more than the inventor claimed, and I maintain that such a practice is essentially unjust. Mr. Imray admits the practice, and defends it in the case of what he calls fundamental inventions. Prof. Forbes has explained how the machinery of the courts is such that wealthy owners of patents can avail themselves of this practice to crush inventors of small means. I have also pointed out that there exists a practice in the law courts of representing a mere improvement in detail to be a fundamental invention, in order to gain the advantage of having the patent stretched. This also Mr. Imray does not dispute; but retorts that the opinion of a mere professor is not worth that of six judges. When I narrow down the issue to particular cases he tries to evade the issue by coining definitions that beg the question, and parables which omit the facts. I submit, then, that my main propositions remain unshaken; and, in closing this discussion, I can only thank Prof. Forbes and Mr. Imray, whose letters have respectively helped to expose and illustrate this blot in the administration of patent law."

THE CHANDLER SYSTEM OF TELPHERAGE.—At Philadelphia last year an overhead wire road for the electric transport of moderately heavy loads was exhibited by a Mr. Chandler. The arrangement is a modification of the well-known system of overhead transport which has been elaborated in this country by the late Prof. Fleeming Jenkin and by Profs. Ayrton and Perry. In Chandler's arrangement there are, however, two cables for each line; these are placed vertically one underneath the other, and the cars or skeps run upon four wheels, two on either cable. The driving wheels are naturally placed upon the upper cable. This method has certainly the advantage of simplifying the electrical connections, and it seems probable that the additional cost is not great. The system is now to be introduced upon a commercial scale by the Suspension Transportation Company, of Boston. At their experimental works at Greenville, several lines have been laid down, and it is said that very satisfactory results have been attained. The employment of the double cable permits the details to be carried out upon a somewhat heavier scale than has hitherto been aimed at in this country. Some of the cars weigh when empty as much as 1 ton each, the upper cable is 2in. in diameter, and the lower 1in. Daft motors are used. It is suggested that the system might be employed for transporting life-saving apparatus along the coast. In this way miles of dangerous coast might be efficiently patrolled, and assistance might be rapidly brought to any required point.

A HINT TO CONSUMERS OF THE ELECTRIC LIGHT.—As the electric lighting season is just now commencing it would be well for those who contemplate electric lighting to place their orders without delay. We believe that in the matter of lighting, manufacturers and others requiring it are very remiss in giving their instructions in time. We have been told by one of the best known electric lighting firms that on speaking to their customers on the subject of electric lighting, they were informed that the "time was too early, they were not requiring lights yet, and that people did not buy candles before they were wanted." This system of procedure will scarcely do with regard to electric lighting. In most cases estimates have to be prepared, and the work of erection has to be

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carried out at the cost of much time and labour, and in some cases it is no easy matter to get the whole system at work in a few weeks. Nevertheless, there are numerous cases in which large and important installations have been carried out with remarkable rapidity. As an instance of this, we are informed that some large mills in the north of England requiring nearly 900 lights were wired throughout and fitted ready for the machinery to be placed in three weeks. It must be remembered, however, that this very quick work entails greater expense on the part of the contractors, and it is to be hoped that those who are intending to use electric light will go into the matter without delay, and by doing this they will possibly save themselves considerable inconvenience and extra expense later on.

THE LANARK SCHEME.—Last week the Town Council of Lanark received a deputation whose object was to request the countenance and influence of the council in favour of a proposal to procure by purchase or lease the water power of Stoneybyres Falls, to be used as the motive power in generating electricity for illuminating the town of Lanark and other places in the vicinity of the falls. Mr. Andrews, of the Woodside Electric Works, Glasgow, explained the project. He also stated that the promoters of the scheme had concluded a bargain with Mr. Walker, proprietor of the land on the south side of the falls, both for obtaining the land they might require, and also for his share of the water power; but they had not yet succeeded in obtaining the consent of the proprietor on the other side of the falls, viz., Sir Simon M'Donald Lockhart. The company, Mr. Anderson said, were prepared to treat with that gentleman in the same spirit in which they had met Mr. Walker, and from Sir Simon's well-known anxiety to promote every good and laudable object, especially when the same would be beneficial to the neighbourhood, he was sure they would not require to wait long before concluding a fair and honourable arrangement with the hon. baronet. Mr. James Symington, Markgreen, and Mr. Hunter, electrician, Lanark, spoke in support of the scheme, as did also Mr. James Chalmers, architect, Glasgow. The council, after a short consultation, agreed to give the scheme all the support they could, and a committee was appointed to aid the promoters.

THE EVOLUTION OF THE TELEPHONE.—At the recent meeting of the American Association for the Advancement of Science Prof. Dolbear read a paper on "Early Telephone Apparatus," and quoted the following passage describing the Bourseul telephone from the *Didiskalia*, September 28, 1854:—"Suppose that a man speaks near a movable disc, sufficiently flexible to lose none of the vibrations of the voice, and that this disc alternately makes and breaks the current from a battery, you may have at a distance another disc which will simultaneously execute the same vibrations. An electric current traversing a metallic wire changes a piece of soft iron in the vicinity of which it passes into a magnet. As soon as the current ceases, the magnetic quality ceases. This magnet (the electro-magnet) can thus alternately attract or let go a metallic plate. It would be possible to so arrange this second metallic plate that it repeated simultaneously exactly the same vibrations as the first plate, and it would then be exactly the same as if one had spoken in the immediate vicinity against this second plate, or the ear would be affected precisely as if it had received the tones directly through the first metallic wall." Prof. Dolbear also gave another quotation on this subject, which has not, we think, appeared in this country. In an article in the *Deutsche Klinik*, 1863, Dr. Clemens, writing on "Disorders of the Spinal Marrow and their Treatment by Electricity," appended the following footnote:—"This most wonderful phenomenon of the transmission of sound in the electrified wire I have observed once before, about ten years ago, in the following manner: A strong induction coil was operated by one cell of battery, and the current conducted above ground through a copper wire several hundred feet long from my study to a distant garden house. As soon as the wire thus extended was attached at the further place to a strong coil, one could hear in the farther coil quite distinctly the running of the machine and likewise perceive at the second coil any sound which was able in any way to set up strong vibrations. Shouting into a funnel, blows upon a metallic plate, &c., if directed towards the induction coil, were heard distinctly in the farther coil, like the tones of an Æolian harp."

THE CHROMIC ACID BATTERY.—We have been favoured with the following copy of results which have been obtained in the course of some experiments with a chromic acid cell:—"The tests described had as their object the measurement of the E.M.F. of the chromic acid cell, firstly, on open circuit when no work was being done, and secondly, when furnishing a relatively large current. The local action due to osmose was also observed. The materials used for these experiments were those usually met with in regular commerce, namely, commercial zinc, carbon, sulphuric and chromic acids. As a preliminary experiment, a cell was made up and left standing for a fortnight, in order to observe the action of any osmose, which happened to be considerable, the zinc being eaten entirely through before ten days had elapsed. The zinc had been amalgamated, but no mercury was left in the cell, as in Fuller's arrangement. The E.M.F. of the cell was measured after it had been made up ten days, and was found to be 2·12 legal volts, and notwithstanding the very bad state of the cell, the recovery of the E.M.F., after being short-circuited, was very rapid, and the measured E.M.F. subsequently showed considerable constancy. Another cell had in the meantime been put together with the same carbon and a similar piece of zinc, the electrolyte being precisely as in the former cell. This was tested immediately it was made up, and the E.M.F. was found to be 2 22 legal volts. It was then short-circuited, and the current passed was about 1·5 ampere; the E.M.F. fell about 2½ per cent., but recovered its normal value in about six minutes. This experiment and several others of similar nature showed the rapid depolarisation effected by the chromic acid. This cell was left for two days in order to observe any action on the zinc, and as it seemed to be considerably affected some mercury was put in the porous pot for continuous amalgamation. Directly after the mercury was added a test was taken, which showed an immediate rise in the E.M.F. of about 2 per cent. The tests made afterwards from day to day during a week showed a remarkably close agreement amongst themselves, amounting to about ± 0·6 per cent. in the E.M.F. The mean E.M.F. obtained from the whole series of experiments was about 2·18 legal volts. From the above tests the following conclusions may be drawn:—(1) The E.M.F. is high and very constant. (2) The depolarisation is very good, and, consequently, the cell can be used for lighting purposes with advantage for small installations. (3) The local action is apt to be rather great, so that it would be advisable to use a solution of different strength in those cases where the zinc has to be left continuously in the solution, as, for example, in telegraphic uses (later experiments with weaker solutions gave better results). (4) It is very readily cleansed, there is no smell, and the solutions are easily made up and no solid salts are formed. The tests were made with a Thomson reflecting galvanometer, and a standard condenser. The standard of E.M.F. used was Clark's element. Each observation was made usually five times, and the values calculated from the arithmetic mean of those observations."

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THE ELECTROLYSIS OF SILVER AND COPPER
AND
Its Application to the Standardising of Electric Measuring Instruments.*

BY THOMAS GRAY, B.Sc., F.R.S.E.

This paper contains an account of a large number of experiments on the electrolysis of silver and copper and its application to the standardising of electrical current and voltmeters which have been made during the past year in the Physical Laboratory of Glasgow University; it forms a summary of the reports made from time to time to Sir William Thomson on this subject.

In the earlier experiments pure silver sheet and solutions of pure silver nitrate were used for the electrolytic cells. The results obtained with these cells confirmed those obtained by Kohlrausch, Lord Rayleigh, and other observers as to the great accuracy obtainable with silver, and also as to the nature of the deposit and the care required in the manipulation of the experiment.

* Paper read by J. T. Bottomley, F.R.S.E., before the British Association at Birmingham. Revised by the Author.

The cathode plate consisted in almost all cases of a sheet of pure silver placed with its plane vertical between two parallel sheets of the same metal. In a few experiments a platinum bowl was used, very much in the same manner as that described by Lord Rayleigh in his paper to the Royal Society, but generally the plates of sheet silver were preferred. The mode of treating the plates both before and after the deposit was upon them is fully described, and it is pointed out that when the plate is made thoroughly clean and its size properly proportioned to the strength of the current to be measured, the deposit is finely crystalline and adheres very firmly to the plate. The best results were obtained when the current density at the cathode was between the $\frac{1}{200}$th and the $\frac{1}{600}$th of an ampere per square centimetre of the surface on which the deposit was taking place, the solution being supposed to contain 5 per cent. of silver nitrate. It is also pointed out that the loss of silver from the anode can be used satisfactorily as a check on the amount of silver deposited on the cathode, but that the current density at the anode must be considerably smaller than that which will give good deposits on the cathode. About $\frac{1}{400}$th of an ampere per square centimetre is stated as the maximum current density at the anode which can be safely used if the loss of silver is to be weighed. A

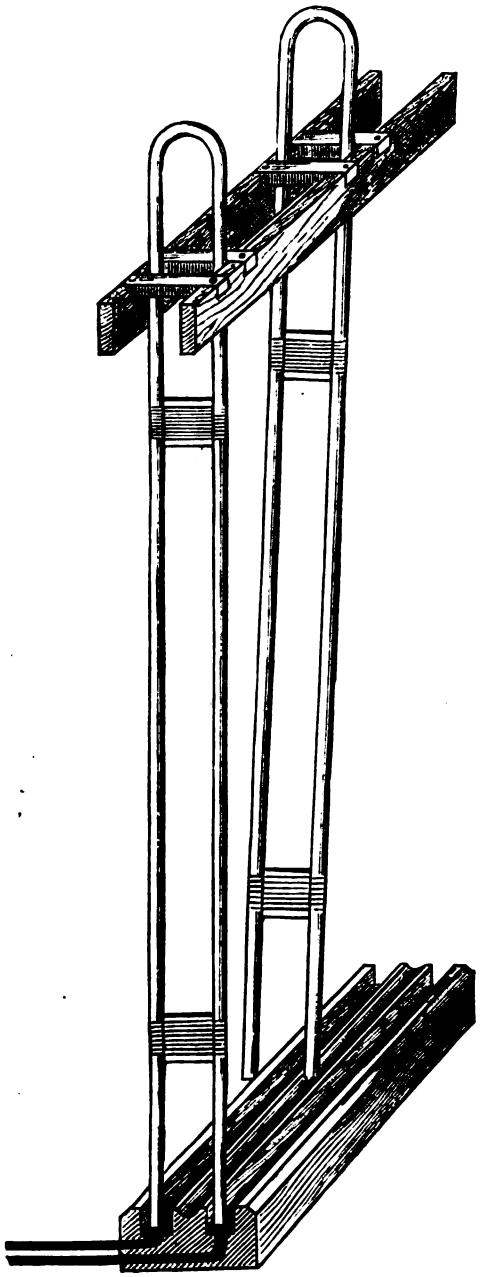
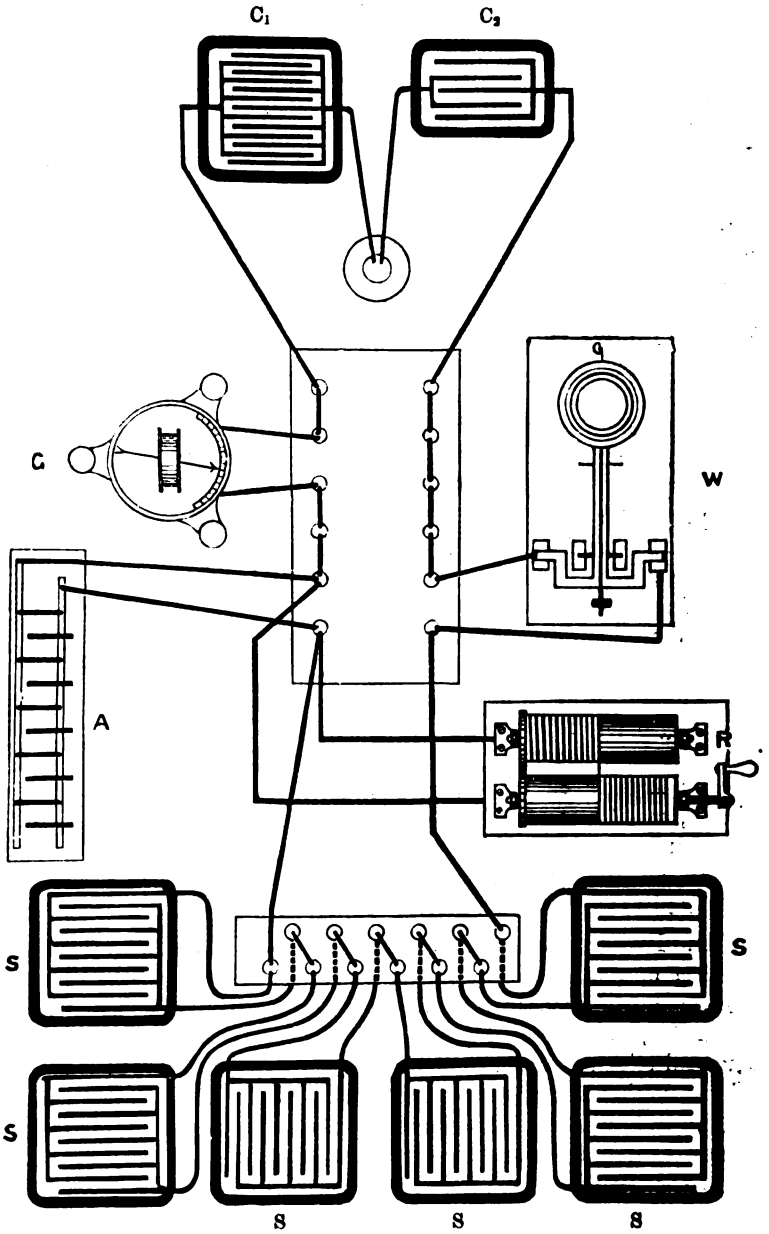


Fig. 1.—View of Conductivity Bridges.



S, Accumulators; A, Conductivity Bridges; C_1 C_2, Electrolytic Cells; R, Rheostat; W, Current Balance to be Standardised; G, Galvanometer.

Fig. 2.

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somewhat greater current density may be used at the cathode if the strength of the solution be increased, but the deposit becomes more roughly crystalline and less adherent. The current density cannot be increased in nearly the same proportion as the increase in the amount of silver nitrate in the solution, and hence when sheet silver cathodes are used the most economical and most satisfactory method is to use weak solutions and large plates. Rolled silver gives unsatisfactory results until the outside skin has been removed by use, polishing, or scraping. The later experiments described in the paper refer, for the most part, to copper and, include experiments on the uncertainty likely to arise from the oxidation of the plate in drying and while in the solution; the effect of the loss of weight due to direct chemical corrosion of the plates; the effect of density of solution; of size of plate or current density; and of the addition of acid to the solution. It was found that there is no difficulty in washing and drying a plate without oxidising it sensibly, and methods are described for doing this. The loss of weight by corrosion in the liquid introduces an error which is nearly proportional to the surface of the plate exposed, and, judging from Dr. Gore's experiments, it is also no doubt influenced by the temperature, if that be not constant; but the effect of temperature was not investigated. The amount of corrosion is also influenced to some extent by the density of the solution, and appears to be least when the density is between 1·15 and 1·10; it is diminished by the addition of free acid to a strong solution.

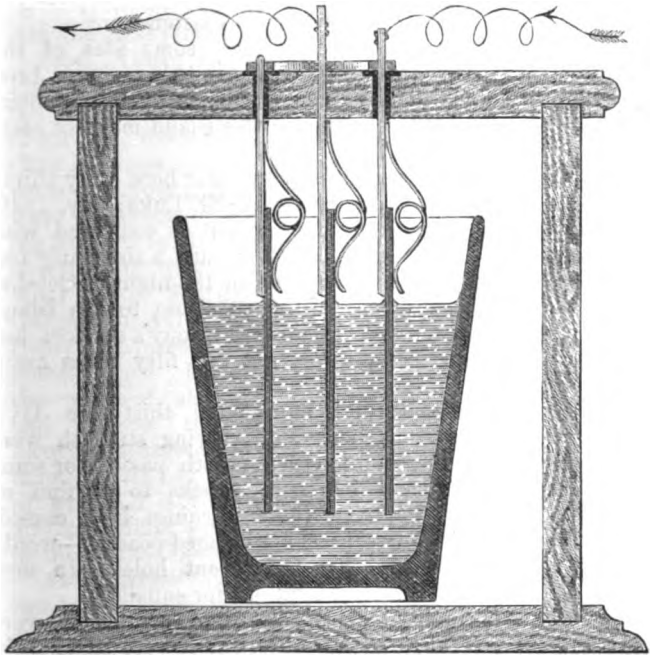

FIG. 3.—Sectional View of Electrolytic Cell.

It is concluded that in the use of copper for standardising purposes, the current density and the density of the solution must be known, and the proper correction made on the electro-chemical equivalent to suit the particular circumstances. If this be attended to copper is capable of giving results within a tenth per cent. of accuracy, and is much more easily managed than silver. Silver is preferable for the highest accuracy, but the accuracy which copper is capable of giving is easily obtained, and it seems sufficient for most practical purposes.

Experiments on the ratio of the electro-chemical equivalent of copper to that of silver were also made, and led to the conclusion that when the proper correction for corrosion in the liquid is introduced, the ratio is very nearly 0·2942, which, on the assumption of ·001118 as the mass in grammes of the silver deposited by 1 coulomb of electricity, gives as the corresponding number for copper ·0003290. When a nearly saturated solution of copper sulphate is used and a current density of $\frac{1}{30}$th of an ampere per square centimetre of the cathode, the amount of copper deposited by a coulomb of electricity is ·0003287 gramme.

It is pointed out that if the solution does not contain free acid there is a danger of obtaining too great an increase of weight, due apparently to the oxidation of the copper as it is being deposited. The same remark as that made above with regard to the silver anodes, namely, that they must be considerably larger than the cathode, applies to the copper anodes if they are to be weighed. If the copper anodes are so small as to give a current density exceeding about the fortieth of an ampere per square centimetre, the current is liable to stop almost completely, even when an electromotive force of as much as 25 volts is used to produce it; this is apparently due to excessive resistance at the surface of the anode. After a few minutes the current again resumes nearly its old strength, and gases are given off freely at the anodes.

These gases are readily dissolved by the liquid, and generally as the final result the gain and loss of copper do not differ very greatly, although they always do differ from those obtained when no gases are given off.

The arrangements of one of the standardising tables in Sir William Thomson's laboratory are illustrated, and the different pieces of apparatus and the mode of using them described. The method of standardising instruments which are designed to measure either very weak or very strong currents is also illustrated and described. In the former case a multiple, and in the latter case a sub-multiple, of the standardising current is passed through the electrolytic cell.

DISCUSSION.

Prof. SILVANUS THOMPSON desired to know what galvanometer was employed for keeping the current constant.

Mr. BOTTOMLEY replied that any instrument that was sufficiently sensitive might be used.

Prof. THOMPSON said he supposed all the measurements assumed H constant.

Mr. BOTTOMLEY said H remains nearly constant during the hour. He did not know whether he had been misunderstood. The object of the whole thing was to standardise a current measuring instrument by electrolysis. The value of H did not enter into the result.

Prof. THOMPSON was afraid H would not remain constant for an hour in his laboratory among dynamos, &c.

Lord RAYLEIGH said he supposed the constancy of the galvanometer was not an essential part of the apparatus. In point of fact, when he wanted to obtain the highest accuracy he found it was best to leave the current alone, and take the mean of the current readings at the beginning and end of the time. Of course it was far more convenient for calculation to control it in the way Mr. Bottomley had described, by means of the galvanometer and rheostat.

Mr. BOTTOMLEY: That is quite so; it is simply for convenience.

Lord RAYLEIGH said he would like to know whether Mr. Bottomley did not find, in using a vertical arrangement of plates, whether of silver or copper, that he was troubled with the necessary tendency of the liquid to assume unequal density. It might be that with large masses of liquid the effect was not important; but in his experiments with silver he had found it decidedly an advantage to keep the plates horizontal, having the anode horizontal near the surface so that the liquid which collected there might circulate itself by gravitation about the plate. He questioned whether it was really the best plan to pass such very heavy currents as Mr. Bottomley spoke of—from 50 to 100 amperes—through voltameters at all. It would not be very difficult to contrive apparatus, a sort of shunted galvanometer, which should show with precision when one current was exactly twenty or thirty times another. In that case the heavy current to be dealt with would be passed through the instrument to be standardised at the same time that the current twenty or thirty times smaller passed through the voltameter. That occurred to him as the best way of measuring very great currents with great accuracy rather than to pass the great current itself through the voltameter.

Mr. BOTTOMLEY said, with regard to the density question, they had not been troubled with the change in density. They had a large number of plates; there were in all nineteen in their instruments, nine cathodes and ten anodes, and an electrolytic vessel containing perhaps 30 or 40lb. of solution. They were brought close to each other, and no doubt current must be circulating in them. He thought large currents, 200 amperes or more, a method of graduating somewhat similar to that Lord Rayleigh had referred to, would be useful. Sir W. Thomson has occasionally graduated two or three instruments with smaller currents, then putting these in multiple arc, taking the whole current from them through an instrument to be graduated with a strong current, and has had very good results

Prof. BLYTH wished to know something more respecting the rheostatic interference with the current strength during the period of measurement. Was it exactly the same thing in measuring the quantity of electricity going through the electrolytic apparatus if it were applied for ten alternate periods of one minute, and then for ten consecutive minutes? He could not quite see why it should not be, but it was quite possible that it might not be exactly the same thing. If it were, the rheostatic interference with the current strength during the time of measurement would require to be seriously looked into.

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Mr. SHAW said he had seen a number of experiments on the comparison of silver and copper electrolytic cells, and he would like to remark upon one point introduced by Mr. Bottomley, who had spoken of the determination of the quantity by the loss of weight of the anode as well as by the gain of weight of the cathode, and mentioned a difficulty which those who worked with copper voltameters were perfectly familiar with, that was to say, that after a current had passed for some time it very rapidly fell. It might recover again two or three minutes afterwards, but there was that sudden drop in the current which sometimes seriously interfered in experiments with standardising instruments. That seemed to him to be due to the oxide in the copper, or whatever the anode might be; but, as a matter of fact, it wiped the layer off, and a rehabilitation of the current was at once obtained. Even in the case of silver, although the oxide did not occur there, the current in its action upon the anode seemed to be selective; it did not take a uniform layer, but disintegrated the metal as it took off the silver, and that, although it might be reduced to a minimum in certain particular experiments, could never by any arrangement of the apparatus, so far as he could make out, be actually avoided. A particular experiment might succeed in consequence of the peculiar molecular construction of the silver, but generally the result was greatly interfered with by reason of this disintegration and consequent falling away of the metal. The hard or oily layer on the surface of the silver was very apparent, but even when they got below that and used surfaces originally left by electrolytic action—even there, there was a selective action of the current upon the anode, and it was only when the anode was of considerable size that any satisfactory weighing of the anode could be obtained. The current he had worked with was very much smaller than the currents Mr. Bottomley had mentioned, being about half an ampere or less. This difficulty must be very considerably increased in this case, owing to the proximity of the plates.

Prof. ARMSTRONG asked Mr. Bottomley what method of drying he had employed. Of course chemists now obviated the difficulty in this respect by drying very rapidly, usually by washing first of all with distilled water, and then with ether, possibly to dry the plates after the washing. He spoke of this because chemists were in the habit of using electro-deposition for a very large number of determinations.

Lord RAYLEIGH supposed Mr. Shaw's remarks related rather to the anode than to the cathode.

Mr. SHAW: Yes.

Mr. BOTTOMLEY did not know if anybody had made any experiments on a subject mentioned by Prof. Blyth, that of starting and stopping the current. He did not see why stopping and starting should make any difference, though it would make instruments difficult to read. With regard to weighing the anode plates, it was only used as a check upon the other method; they really went by the cathode. If the anode were to give a bad result it would be put aside. It was mentioned only as a matter of interest, and as showing that the anode could be used if the dimensions were properly arranged. With regard to drying the plates, they simply put them between two folds of blotting paper, squeezed the water out, and then exposed them to the fire or to the hot current of air over a spirit flame.

Prof. OLIVER LODGE said he had always found the copper come out 1 per cent. higher than the silver result. He supposed, however, the method was sufficient for rough graduation. The difficulty in drying copper and weighing it before oxidation occurred was very much too considerable for accurate working; silver was very much easier to deal with.

Prof. SILVANUS THOMPSON said that checking the current after first turning it on could to some extent be avoided by using small current density. An experiment given in the first chapter of "Planté's Researches on Secondary Batteries" was admirably calculated to show the three stages of the process occurring at the first turning on. The phenomenon was most marked when two copper wires were used as electrodes with a very considerable current density.

Mr. BOTTOMLEY said he should be very sorry if it was supposed that the experiments described in the paper were merely for the purpose of rough graduation. They considered that the experiments were good to $\frac{1}{10}$th per cent., and it was not a matter of being sure to 1 per cent. or anything like it. He thought if the precautions which they had discovered to be necessary in the course of these experiments were adopted no very serious difficulty would be found in the way of washing or drying the plates. The plates obtained and treated in the way described were obviously not oxidised; after drying them they could leave them for hours, and the weight was not perceptibly different. The great thing was, perhaps, with regard to avoiding the oxidation during the time when the current was flowing, and that was accomplished by making the solution of the proper density, and keeping it slightly acid. In neutral solutions they always found oxidation, and to a very serious extent.

Mr. SHAW said he could corroborate Mr. Bottomley's statement with regard to the oxidation of the anode when the current density was adjusted with sufficient carefulness. For other current densities the oxidation was equally marked as soon as the plate began to dry. This was a point upon which he was having some communication with Prof. Lodge for the purposes of the Electrolytic Committee, and therefore he would say no more about it at present.

EXPLOSIONS OF ELECTROLYTIC GAS AND VOLATILE CARBON COMPOUNDS.—Signor A. Pizzarello contributes a paper to *Il Gazetta* showing that when electric sparks are passed through electrolytic gas saturated with the vapour of a volatile carbon compound, such as ether, ethyl and methyl alcohols, or ethyl formate, a coloured flame is noticed during the explosion, and a small quantity of carbonic oxide is produced.

THE EARTHQUAKE IN GREECE.—Special Report.

(FROM A CORRESPONDENT.)

ZANTE, SUNDAY, AUG. 29, 1886.

If the unfortunate inhabitants of the Ionian Islands and the Morea had been led to hope that the unusually long immunity from earthquake shocks indicated that they had possibly taken another direction, the illusion has been most rudely dispelled by an earthquake of a character more general and extending over a wider area than Greece has ever previously been visited by.

Many local phenomena as far back as last January, including the stoppage of the ooze from the pitch wells here, subterranean rumblings of a most pronounced character, unusually prolonged calms, and high water, prepared us for something extraordinary.

The whole of the past week had been peculiarly strange. Heavy clouds, which generally discharge their accumulated electricity at this season, remained stationary over certain points of the horizon. The temperature varied but one degree between noon and midnight, averaging 85 F., and by the observant sounds and noises of an unaccountable nature were noticed during the still small hours of the night. The news which had just reached here of the reported volcano some hundred miles south of this island tended to increase our alarm, as former experience (about which I will inform you presently) led us firmly to believe in its existence.

In order that your readers may form some idea of the idiosyncrasies of earthquakes, especially in this region, a brief history of those which have come under my personal notice during a thirteen years' residence in this island may not seem out of place.

It is a tradition that serious shocks occur here every thirty or forty years, and the strong shock of St. Luke's day, 1840, is cited as the last one severely felt, and it is compared with the present one. The Greeks, however, are a singularly forgetful people, and do not now remember the night of October 26th, 1873, when a subsidence of the sea close to the island caused far more damage *locally* than last Friday's shocks; but its area was very limited, and was not felt fifty miles away from its centre.

After that shock the earth moved for thirty-five days, and from five to ten shocks of varying strength were daily registered by me, and never a month passed for some years after without one or more shocks to remind us to beware. Latterly, however, these warnings have ceased, and that true historian of real facts—the aged peasant—would shake his head and declare that the "vent holes were now stopped, and we must therefore look out for squalls."

As a rule, hitherto any local shocks, however distinct, were rarely felt in neighbouring islands, and were classed in the same category as those I have described, viz., strong shocks occurring periodically after an interval of a number of years when the frequent small shocks had ceased.

On the 28th of March, 1885, at 8:25 p.m., whilst sitting at dinner, a violent undulation of a peculiar nature, and of a decided though distant force, occurred in Zante.

In a few days it was fully proved that a most extensive subsidence of the sea's bottom had taken place some eighty-five miles to the south of Zante. In certain places, where a depth of 800 fathoms previously existed, 1,500 and 1,900 were then found, and in others, hitherto measurable, no bottom could be found.

In one place, where the bottom had been previously quite level, a difference of 350 fathoms existed between the bow and stern soundings of the "Volta," the Eastern Telegraph Company's repairing ship, engaged in the repairs of the cable broken by this subsidence. It was generally considered advisable that a surveying man of war should take fresh soundings, as those marked on the Admiralty chart of 1864 must now be a very long way out.

How far this subsidence extended it is difficult to form an idea, but that it was volcanic is undoubted from the following

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event which took place some few years before :—In the month of August, 1880, a huge black cloud about two miles in height, shaped like a great pine tree, extended over the south of t Island of Zante. The origin of this smoke was within 150 miles of us, in a position where the chart shows 1,200 fathoms of water.

As the smoke gradually extended calcined leaves of a putrid nature, hot ashes, and fine fibrous matter fell all over the place. One charred, but perfectly formed, leaf fell right upon my own arm, and was kept for some time as a curiosity. Some readers may remember these facts, for an account of them was telegraphed home by me at the time, and gave rise to all kinds of conjecture.

There can be no longer any doubt that the upheaval there, the subsidence of the sea's bottom, and the earthquake of last Friday all originated from the same source, and it is a most unpleasant thing to know we have such a dreadful neighbour ready to engulf us at any time.

When the earth began to rock at twenty-seven minutes past eleven last Friday night, the movement was perfectly equal, undulatory and unaccompanied (fortunately for us) by any "kicks." It was in a pronounced direction from the south-east, and was preceded by a noise which we took for a steamer close at hand. It is variously estimated that the shock lasted from 15 to 40 seconds, but seconds are centuries in such supreme moments, and who can think of counting them? For my own part I should say 20 seconds was about the duration. The consternation was, of course, general; but my thoughts were far away where I knew the centre of that shock had its origin, and the next morning our fears were fully confirmed.

From Kastro Tornese, the prominent ruined castle in the Peloponesian shore, opposite Zante, that gloriously fertile tract, the real Arcadia of the ancients, stretches itself away to the southward, towards the Gulf of Calamata, the storm beaten Cape Matapan, and the opposite Island of Crete, the first place we come across is Katacolo, the port (and connected by a railway) of Pyrgos, one of the greatest and richest currant growing districts in all Greece, the average produce amounting to nearly forty thousand tons. Further to the south are the other rising, flourishing, and at this season busy towns of Gargaliano, Aghia, Kyriaki, and Filiatra, and the limit of this richly cultivated part of Greece ends at Calamata. All these places have been most seriously damaged, Filiatra the worst of all, not a single house remaining standing, and up to the time of writing 120 dead bodies have been extracted from the ruins. At Corone, close by, many houses fell, and thirty people were killed. The number of wounded is very considerable at both places. Calamata and its vicinity suffered proportionally less, being too far south of the earthquake's centre.

At the larger town of Pyrgos, a place of some ten thousand inhabitants, with many fine and apparently strong houses, it seems a simple miracle that there were few or no victims, as the houses have been so generally and seriously damaged that the whole place is unrecognisable. The damage alone at this place is calculated at about two million francs.

All the Ionian Islands felt the shock most severely, especially Corfu, where the high stone houses render such visitations particularly dangerous — in fact, earthquakes were hitherto unknown there, and consequently it is an exception to find in that island the low built houses we have here and in the Morea. Athens and Patras sensibly felt the shock, as also several towns in the south of Italy, and the same appears to have been experienced at Malta. It is calculated with the greatest degree of certainty that in a circle of 300 miles radiating from its centre the whole of the earthquake's effects can be traced.

There is not the slightest shadow of doubt that this centre was in the sea and pretty close to the reported position of the supposed volcano, for the nearest place in a direct line between it and Malta is this unfortunate town of Filiatra.

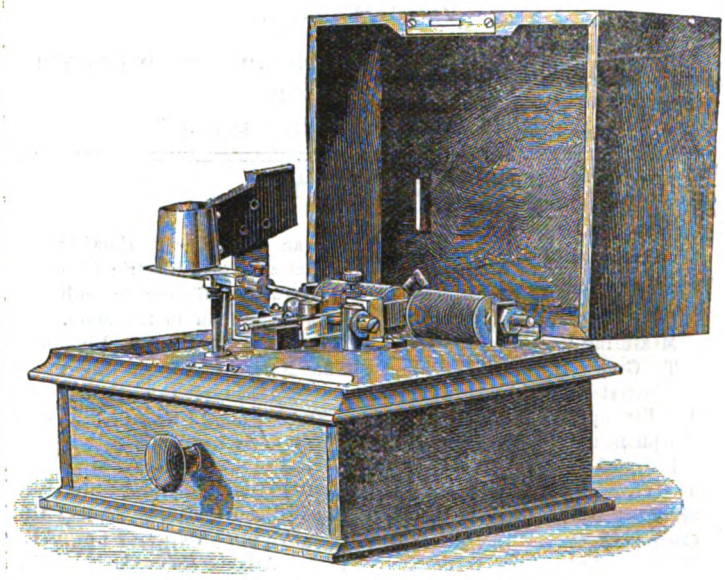
I am fully persuaded that if the whole sea between Zante, the islands of Strofades down to Cape Matapan, were surveyed, it would be found that the sea bottom, for some ten to thirty miles, has regularly given way.

None of the phenomena peculiar to regular magnetic disturbances accompanied this earthquake. It was precisely as you would see the waves roll overlapping each other, if a mountain were steadily lowered into the sea. Nothing else can be compared to the movement we experienced. Had, however, the swaying stopped half way, to begin again with the usual "kick," I am persuaded that the western coast of the Morea and the Ionian Islands would only now exist as places "that were."

The Greek Government immediately sent doctors and supplies to those places where help was most needed, and the misery will be less severe if the weather, hitherto menacing, keeps fine, to enable the currant crop to be collected, as the only income of two-thirds of the Greek population is derived from that source.

TELEPHONE CALL APPARATUS.

The privilege granted by the late Mr. Fawcett, as Postmaster-General, to the Telephone Companies to open public Telephone Call Stations where anyone could use the Telephone Exchange by paying a small amount, has resulted in a further development of telephonic apparatus in the shape of telephone "toll" instruments, and the first in the field in this country is that known as the Crossley, Harrison, and Emmott call box.



The Crossley, Harrison, and Emmott Call Box.

In this instrument (shown in the figure) a slit at the top of the box enables the person wishing to use the telephone to deposit the necessary amount, which is usually 3d. for inter-town communication.

The coins roll on to the table shown at the end of the lever, and, overbalancing it, they fall into the drawer seen in the lower part of the figure. The movement of the lever thus obtained puts the telephone in connection with the exchange by means of a contact which is maintained so long as the operator at the exchange shall permit, the specified time being three minutes, at the expiration of which time a current is sent from the exchange, which throws the needle of the relay to its normal position, and until a second toll has been deposited no further communication can be made. The movement of the lever has been used to start a train of clockwork, and thus take the regulation of the time out of the hands of the operator; but in many cases this is considered unnecessary, and it is preferred to keep the apparatus in the form shown, as the call boxes are often placed in remote country districts, where the number of calls are insufficient to maintain a telephone exchange or attendant, and simplicity, with non-liability to get out of adjustment, is the first thing to be considered.

A counter attached to the lever enables the number of calls to be registered, in order to keep a check on the cash.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

All communications to be addressed to 1, *Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

VOLUME XVI.

Volume XVI. of "The Electrician," price 10s. 6d., is now ready.

Also cases for binding, price 2s.

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THE VOYAGE OF THE "VOLTA."

Although no exaggerated value, either scientific or technical, is said to be attached by the owners to the experimental trip of the "Volta" across the Channel last Monday week, the feat is one which they may well be proud of, and the notice it has attracted in the press cannot fail to add greatly to the reputation of Mr. RECKENZAUN, who was responsible for all the electrical arrangements of the expedition. If the good people of Dover really imagined that the "Volta" was about to be put in competition with the "Calais-Douvres," these modest disclaimers on behalf of the electric launch are perhaps not uncalled for; but the voyage was not made for nothing, and Mr. RECKENZAUN is probably more confident than he cares to own that the propulsion of boats by electricity will soon cease to be a day's wonder, and will eventually take its recognised place among the practical modes of marine locomotion. At all events, there are several ways in which already it may be conjectured that electrical navigation will establish its superiority over steam; and some of these are indicated by the results of this voyage from Dover to Calais and back.

In the first place the "Volta"—which may be taken as a type of what boats of her class will be—is undecked, and her accommodation for passengers or merchandise is, therefore, greater than that of any boat of similar dimensions driven by steam power, and carrying the requisite supply of coals. At the same time it is needless to say that an open boat of this description is not adapted for the sea except in very calm weather. Her batteries are stowed away where fuel could not be accessible; and her motors take up far less room than the engine, boiler, and funnel of an ordinary steam launch. Next, there is the avoidance of all those annoyances to passengers which are the invariable attendants of steamboat travelling, even when the journey is short and the water smooth. The "Volta" makes progress without any disagreeable vibration, and with no smoke or bad smells. The noiseless way in which she glided on the water the other day was demonstrated by one of the crew laying hold of a sleeping seagull, whose slumbers had not been disturbed by the approaching boat. And, lastly, the speed at which a launch of this description would be propelled on ordinary occasions is as great as that of the average steam launch, but can be increased beyond anything a fast sailing steamer is capable of if special occasion call for it.

When the steamboat was first constructed, its employment seems to have been confined to inland waters or narrow streams; and even as late as 1812, some fourteen years after MILLER'S first experimental boat on Dalswinton lake, Dumfriesshire, the more ambitious designs of FULTON in America were only employed as ferry boats, their speed not exceeding seven miles an hour. Probably for some little time to come the electrical boat will confine itself to the same narrow sphere of operations, its usefulness being at present limited by the necessity of plying between fixed points, not very remote, where fresh fuel—or more exactly a fresh charge of electrical energy—may be taken in. Subject to this condition, however, an objection which effectually hindered the progress of steam navigation on rivers and canals will not apply to the electrical boat. SYMINGTON'S steamboat was interdicted on the Clyde Canal in 1801 on account of the motion destroying the banks. The modern steam launch has gained an ugly notoriety on this very account, as well as for its obtrusive ugliness on rivers devoted chiefly to pleasure. The "Volta" might navigate any canal in the kingdom, or the most crowded part of the Upper Thames without provoking a single imprecation, and her "wash" is said to be comparatively harmless.

If the expense of working can be kept within reasonable limits we believe there is a wider sphere of usefulness open to electrical boats of the "Volta" type; and her passage across the Channel will firmly establish public confidence for journeys of more limited extent. In some cases the water power of rivers to be ferried might be utilised for charging the batteries, and the expenses reduced to a minimum; but under even less favourable circumstances the capacity of the secondary battery is being so greatly enlarged that we may confidently anticipate a speedy reduction in the cost of this description of motive power. Mr. CROMPTON'S remarks on this head at the British Association meeting were most encouraging. The batteries on board the "Volta," weighing only two tons, enabled her to do the double journey, occupying more than eight hours; and probably it could have been easily extended to ten. If this is a fair measure of her travelling capacity the utilisation of such boats for the navigation of certain rivers is almost a matter of certainty. Competition with steamboats may be out of the question; but it is easy to see that the many advantages of electrical navigation will establish it where steam has hitherto

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been inadmissible, and in some cases may supersede the existing steamboat service, at all events for ferrying purposes.

To the more serious business of propelling torpedoes by electricity a good many people are now devoting their serious attention, and probably this recent performance of the "Volta" will give an impetus to the idea. When steam navigation became a practical reality it was sagely predicted that its adoption would diminish the chances of war by increasing the certainty of destruction, and "proportionally lessening the desire for battle." It is certain that naval engagements have been fewer since the general application of steam; and there is a widespread suspicion that the modern iron-clad will be very shy of coming to close quarters. If there is any truth in this "the desire for battle" will be still further cooled by the perfecting of the torpedo as a swift and deadly implement of naval warfare. Electricity as a mode of propulsion would undoubtedly add much to the terrors of this silent messenger of death, and if certain difficulties were overcome in regard to the storing and charging of the batteries, their obvious superiority over steam power would insure their adoption for torpedo warfare. Possibly these difficulties may gradually disappear through the growing application of electricity on board ships of war for electric lighting purposes. Once establish the storage battery as part of the ship's equipment, its transfer to the torpedo boat will be rendered perfectly easy and trustworthy.

SIXPENNY TELEGRAMS.

The newspaper reports of the reply made by the POSTMASTER-GENERAL to Mr. SHAW-LEFEVRE'S question on Wednesday night with reference to the increase of Telegraph business, and the financial results of the change of tariff, varied so considerably that we have been at some pains to ascertain the exact figures given by Mr. RAIKES. It appears that for the six months ended the 31st March last, the number of telegrams under the new rate was 16,787,540, as compared with 11,314,423 during the previous six months of the financial year, when the old tariff was in operation. The income derived under the new tariff, together with the additional amount received in respect of the registration of abbreviated addresses was £22,000 less than that of the corresponding period of the previous twelve months. During the five months of the present financial year—that is to say, up to the end of August last—the number of messages was 17,369,161, as compared with 11,125,794 for the corresponding period last year, the revenue being £3,000 less. As Mr. RAIKES reasonably pointed out, this small deficiency might be made up in the present month—September. It is well to remark, however, that these figures refer only to the number of and receipts from messages, and in no way take into account the extra cost of transmitting the large number of telegrams in excess of those sent under the old *régime*. This item, which naturally must be very considerable, cannot, as the POSTMASTER GENERAL observed, be ascertained for some time. Briefly analysed, the results of the change from the one shilling to the sixpenny tariff are that the increase for the five months has been at the rate of 56 per cent., and for the six months 48 per cent., while the amount received per message has been $8\frac{1}{16}$d. as compared with $12\frac{1}{17}$d., or nearly 1s. 1d. These figures amply testify to the accuracy of the calculations made by the officers of the department who had charge of the scheme; and go far to bear out their expectations that in a short time the accounts will show a balance on the right side.

CORRESPONDENCE.

LITHANODE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reference to the letter under this heading from Mr. Walker Moseley, that gentleman is labouring under an unaccountable misapprehension in supposing that he "unwittingly" manufactured the substance in question when running down a voltaic couple, in which sulphate of lead was the depolarising agent. His lead sulphate was "in process of electrolytic conversion," not into *peroxide of lead*, but into the well-known, though somewhat complex, compound—containing lead sulphide, basic lead sulphate, and metallic lead—which constitutes the "spent" depolariser in the sulphate of lead battery. "A hard, black lump" of *peroxide of lead*, "resting on a layer of minute bubbles of *hydrogen gas*," would, indeed, be an extraordinary phenomenon! No wonder Mr. Moseley objects to the term "lithanode," as being a "dubious title," if he imagines that peroxide of lead can be produced at the *cathode* within a voltaic cell.

Mr. Moseley, as well as other practical electricians using batteries for working electric bells and for many other purposes, has yet to make the acquaintance of *lithanode*. Anything less resembling the residue from the sulphate of lead battery, whether from a physical, chemical, or electrical point of view, it would be difficult to imagine. If he can manage to obtain—there, perhaps, is the difficulty, which I may be able to overcome for him—a plate of lithanode, and if, with a fine saw, he will cut from the plate a narrow strip of the material, he will be able to realise what can now be done in the direction of "small size and cleanliness," as well as in that of general efficiency, in the construction of voltaic batteries. I speak only of the negative element of the couple; but this, as Mr. Moseley knows, is considerably more than "half the battle." With this negative, a fragment (say) of an old meat-tin as a positive, and a little dilute acid—sulphuric or acetic—as electrolyte, he would be able to astonish the good people of Scarborough with a battery presenting a far greater contrast, in bulk and weight, to the sulphate of lead battery, than does even the Leclanché cell.—Yours, &c. DESMOND G. FITZGERALD.

6, Akerman-road, Brixton.

NAVIGATION BY PRIMARY BATTERY POWER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the very interesting account given in your journal of the 17th inst. of the "first occasion on which the Channel has been traversed by electric power," it is stated that the "Volta" was provided with 61 accumulator cells, each containing 39 plates, and that the cells have a capacity of about 240 ampere-hours, which, at 120 volts for that number of cells, is equal to $4\frac{1}{2}$ horse-power for a maximum of $8\frac{1}{2}$ hours when discharging at the rate of 28 amperes. The cells were charged by a dynamo on shore at Dover, and the trip to Calais and back occupied eight hours and five minutes.

Whilst very heartily rejoicing at the success of so notable an expedition, and with a wholesome dread of the consequences which may befall me for venturing to make so bold an assertion, will you permit me to state that the same electrical power would be obtained in a very much more lasting form from 61 cells of a certain primary battery with which I have had some little experience, in each cell of which the 39 lead plates would be replaced by four carbon and five zinc plates? In the 61 accumulator cells there were 2,379 plates, whilst in the primary battery of equal working power there would be only 549, or less than one quarter the number; but, nevertheless, the duration of the voyage, instead of being limited to eight hours, might without difficulty be extended to eight consecutive days and nights, or to eight weeks or more, without its being necessary to return to the shore to re-charge the battery.

During a voyage of eight days and nights (192 hours), if using the same electrical power, viz., 3,360 watts per hour, such a primary battery would require to be from time to time refreshed with liquid, the storage of which need not occupy more than two cubic yards of space; while the steadiness.

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constancy, and freedom from noise would be precisely the same as with accumulator cells. The only difference in working the batteries would consist in using preferentially with the primary double the quantity of current and half the E M.F.—Yours, &c., O. C. D. Ross, M.I.C.E.

East Dulwich, September 18, 1886.

CAPTAIN CARDEW'S METHOD OF TESTING THE EFFICIENCY OF DYNAMOS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Your note on this subject hardly explains the most useful form of this excellent method. It is not necessary to have three machines of identical size and type, but any two dynamos from the stock of more or less antiquated patterns which most makers have the misfortune to hold will do for testing a third.

Let A be the dynamo to be tested. Take B and C, two others of about the same output, so that A be tested to its full load.

Couple B and C together with a belt or coupling, and run them from A as a generator, using B as a motor and C as a secondary generator, and then C as a motor and B as a secondary generator. These tests will probably be identical; if not, the mean may be taken. The ratio of the output of the secondary generator to the output of the primary will, of course, be the efficiency of the pair B C. Call this E_1.

Perform the same with B and C as primary generators, making three pairs of tests.

Then $E_1 = B C$; $E_2 = A C$; $E_3 = A B$.

Therefore $$A = \sqrt{\frac{E_1 E_2}{E_3}}.$$

This system is, as you observe, absolutely beyond suspicion of error, and the most accurate one that can be adopted.

It would be interesting to test some of the much-talked-of mechanical dynamometers by means of dynamos and electrical instruments; and it would not be surprising if the dynamos told tales about the dynamometers in less complimentary terms than these instruments tell when used to pass judgment on dynamos.—Yours, &c., Alex. P. Trotter.

Bull Green Works, Halifax, Sept. 20, 1886.

ELECTRIC LIGHTING IN ITALY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of Sept. 10, under the heading "Electric Lighting in Italy," taken from *Industries*, appears a statement which is liable to a false interpretation by your readers, and I take the liberty of pointing out its inaccuracy.

The plant at Turin referred to in the above article is not an Edison plant, nor was it installed by the Edison Company, nor under its direction. The Edison Company furnished only the dynamos for this installation. The material which has given trouble, including underground lead cables, lamps, &c., was furnished by other parties and installed by the Turin firm holding the concession from the municipality.—Yours, &c.

Milan, Sept. 13th, 1886. J. A. Lieb, Jun.

THE INCANDESCENT LAMP.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: May I ask through your valuable paper why it is that the makers of incandescent lamps will not give more than approximate figures of the current or resistances of the lamps they send out? They will only give, I am informed, the E.M.F. and candle-power. Surely they charge enough for them to warrant the purchaser in expecting to know what actual current each lamp requires relatively to its E.M.F.

I am a great lover of the light, and I believe the method by which it is now obtained is almost perfected, with the exception of the lamps; but here there is not that accuracy and reliability which there should be if economy in the incandescent system of lighting is to be attained.—Yours, &c.,

T. D. C. W.

A CORRECTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: On page 381 of last week's issue it is stated, in connection with the Sunderland Telephone Exchange, that the "multiple" switch-board has just been introduced there, and that only two other exchanges in this country, viz., Liverpool and Glasgow, have adopted this principle.

Will you permit us to say that the "multiple" switch-board has been in use in the Sheffield Telephone Exchange since February of the present year.—Yours, &c,

Tasker, Sons, and Co.

Sheffield, September 21st, 1886.

ELECTRIC INDUCTION BETWEEN WIRE AND WIRE.*

BY W. H. PREECE.

Along the Gray's Inn-road, in London, the United Telephone Company has a line of wires over the roofs of the houses, and along the same road, for a distance of 2¼ miles, the Post Office has a line of telegraph wires buried in iron pipes about 2ft. 6in. beneath the street. The telephone company stated that they observed certain disturbances upon their wires, and on one occasion had been able to read a message that was sent from London to Bradford. Now, inasmuch as the Bradford wire passes through those pipes, it was clearly evident that the disturbance, such as it was, was due to some action between the underground wires and the overground wires. I took every possible pains to determine to what this was due. It might have been due to some accidental contact somewhere between the wires. It might have been owing to conduction through the earth, but by grouping the wires in every possible way it was quite clear that by eliminating the earth and by adopting every precaution that we knew to avoid contact, there was induction between the telegraph wires underground and the telephone wires overhead, the wires being separated from each other by a distance of 80ft. We little anticipated that inductive effect was experienced at such a distance, and I had a series of experiments tried by Mr. Heaviside on the Town Moor, in Newcastle, to determine how far induction between wire and wire could be traced, and there it was found that distinct evidences of induction were felt at a distance of 3,000ft. Having got from 80ft. to 3,000ft., it was then thought that we would see what effect could be found on an actual line. Between Durham and Darlington there is a line of six wires 18 miles long. Between Castle Eaton and Stockton there is a line of 12 wires 10¼ miles to the east. Between Bishop Auckland and Piercebridge there is another line of 12 wires at a distance of 5¼ miles. We took this central line of six wires and 18 miles long and grouped them into one primary wire, and transmitted currents through this primary wire by means of a Wheatstone automatic transmitter—a transmitter that sends reverse currents—and at each of these corners which I mark A B C and D observers were placed with telephones. The effects of rapid transmission of alternating currents at the rate of about 500 or 600 per second were heard distinctly at these four corners; and the notion was that inductive effect was experienced between these lines, the one being 5¼ and the other 10¼ miles away. This experiment took place on Sunday. The lines were isolated at each end, and while everything was perfectly quiet—while the distinctive currents produced by the transmitter on this central line were absent, the observers received distinct indication of Morse signals being sent elsewhere. There was no line near, there was no place where these Morse signals could be obtained but from a line on the other side of England, 49 miles away from this particular place. On the subsequent Sunday we took the lines from Gretna to Shap, a length of 49 miles, and from Jedburgh to Newcastle, a length of 55 miles. On the one line there were 17 wires, on the other 10 wires. I went myself with Mr. Heaviside to Gretna. We had another observer at Shap, one at Jedburgh, and one

* Paper read before the British Association at Birmingham.

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at Newcastle. Now, in order that there should be no possible mistake between the sounds obtained by working the telegraph, a special commutator was used that sent rapid intermittent currents increasing and decreasing so that the sound produced was a rising and lowering wail [imitating with the voice] something like that. However, the sound was so perfectly distinct that, if it were transmitted, it would certainly be evident at Gretna. The experiment was to take place between the hours of eleven and one. At a given time, 11:15, the transmitter was to be put on at Gretna, and at that time I heard a distinct and clear wail. Well, the conclusion that we came to is that an inductive effect took place across this country forty miles broad. But I am bound to say that there are many reasons why the evidence must not be taken as conclusive. Every possible precaution was taken by isolating the lines, but we were still compelled to use the earth. The whole of the north of England is covered by a network of wires. There are wires going from Glasgow to Edinburgh, then again from Carlisle across the country; and, although the experiment is very interesting, I do not say that it is conclusive that inductive effects can be transmitted across such an extent of country. At the same time the evidence is quite sufficient to justify our pursuing the investigation as far as we possibly can. At the present moment we are putting up from London to the Welsh coast a line of copper wires 150lb. to the mile—a perfectly distinct line—and there will be many lengths on that line of forty to fifty miles perfectly clear of lines in any other part of the country, and during the next two months I am going to try several more exhaustive experiments of the same kind. Naturally one is very desirous, having got so far, to get some idea of what this effect was, and some notion of the laws with regard to it. Of course it is full of difficulty. We have conduction through the earth, and we have various other causes that make it extremely difficult. But what I have done is this: A gentleman—Mr. Hugh Andrews—gave us the use of his park (Swarland) for some of our experiments. They have been going on for eighteen months, and hitherto we have been able to make many both there and upon the moors. But as regards the latter a difficulty arose—namely, the grouse—which compelled us to go to the park I have referred to, and there we laid out the wires in various forms to try the distance through which this effect was produced. I will not give you all the details, but I will simply give you one of the results that we arrived at. A circuit was made of gutta percha covered wire a quarter of a mile square—that is, a circuit of copper wire covered with gutta percha laid on the ground on a square of a quarter of a mile. Another similar square was laid on the ground, and many other squares of different sizes, forms, and shapes were put apart from each other. The results of those experiments will form the subject of a subsequent paper. Lord Rayleigh has kindly promised to assist me in this matter. It requires a considerable amount of mathematical knowledge to work out the formulæ and conditions that may arise, so that I hope next year I may be able to give you some of the results. But now the result I have got is this—that, with a square fixed at a distance of a quarter of a mile from an exactly similar square, it is quite possible with a telephone in one square to speak to a telephone in the other square, separated by a distance of a quarter of a mile. There is no earth there; there is no disturbance; there is nothing that could possibly enable a listener in one telephone to hear a speaker in the other telephone, except inductive effect across that layer of air a quarter of a mile in length. It is not necessary even that air should be the medium between the two. Since these experiments were made, I have learned from Porthcurnow that our cable to the Scilly Islands was broken down, and half a mile from this Scilly Islands cable there is another cable, belonging to, I think, the Jay Gould Company, to Brest. These cables lie in the water half a mile apart. They do not come near each other, and yet the signals on the Scilly cable were heard distinctly, and the messages transmitted on the French cable half a mile away were read with perfect ease. There we have induction it would almost seem in the sea. I am not quite sure but at the meeting at Southampton I showed how we had spoken with the Isle of Wight from Southampton without any wire across the Solent. This was evidently by induction. Mr. Edison, of America, has been working in this direction, and he has been able to communicate with passing trains. Trains carry induction coils, and they send their inductive influence to the wires along the line, and conversation has been held in that way. There is no doubt that this inductive influence will lead to further inquiries, and probably eventually to a more extensive practical development of the telephone.

Discussion.

Sir W. Thomson said that the question of induction over an area of 40 miles was an interesting one from many points of view, and one which he hoped Mr. Preece would be able by-and-bye to say more about. Mr. Preece, however, had indicated a means by which messages might be communicated, or partially communicated, by the cross telegraph wires that covered the north of England, and they would look forward with the greatest interest to the results of the continued experiments that Mr. Preece had promised. The case of the two squares was something very definite, and he had no doubt that Lord Rayleigh and Mr. Preece would follow it up and bring it to a mathematical certainty. Nothing could be more interesting from a purely scientific point of view, and it was obvious that it might be of practical use. When one spoke into a telephone it seemed now as if one spoke over the length and breadth of the land. The discovery might be taken to show the necessity for taking means to insure secrecy in telephonic communication. Now that they had that wonderful tale-tell or eaves-dropper—the telephone—they could hear what was going on all over the country, and if secrecy was to be obtained, it must be by adopting a thoroughly secret code.

Prof. Silvanus Thompson said he desired to protest against the somewhat general use of the word induction to explain away every phenomenon of the kind described. He knew that telegraph engineers were for ever attributing to induction everything that disturbed their work, when the fact might be simply due to dirty insulators. He himself could not believe that the experiments conducted by Mr. Preece gave an illustration of an effect of induction at all, for this simple reason. They knew that a current in returning through the earth did not, as some people imagined, run straight along the ground underneath the wire, but spread out into a current sheet and flowed round in curves from one earth plate to the other, very much as the lines of force of a magnet curve round from pole to pole. The result of this was that if a neighbouring line, or even one many miles away, had its two ends put to earth anywhere on one of the curving lines of flow, a portion of the return current of the first line found its way through the second line. But this was not induction at all. A case occurred not long ago in a telephone installation which he knew something about in the North of Ireland, where the telephone wires were laid parallel to an electric tramway. The engineer of the line reported that it was hopeless to work it, there being such an amount of induction on the line that it kept on ringing the bell. But that could easily be obviated by putting in a return wire, which was the cure he suggested, and which was found to be perfectly satisfactory. He took exception to Mr. Preece's remarks with respect to the two cables at the Scilly Islands. If there was one thing that would prevent induction it was to have a piece of metal or other good conductor between the primary coil and the secondary wire in which currents were being induced. The surrounding conductor absorbed all inductive effects into itself. In the case of the Scilly Islands there was one cable entirely surrounded by the sea, which was a comparatively good conductor, and, therefore, he entirely declined to believe that induction was going across from one cable to the other. What happened was that some of the current was going along the earth, and a portion of it found its way by conduction to the other cable. He wished to enter a mild protest against the somewhat miscellaneous use of the word induction.

Prof. Blyth quite agreed with Prof. Thompson that the phenomena described might to a great extent be due to conduction through the earth, but at the same time he looked upon the results of these two square experiments as deciding the question that induction between them did take place, and when they called to mind the experiments of Prof. Tait, which were made shortly after the invention of the telephone, and which showed that the telephone could be sensitive to extremely small currents provided they were interrupted with a sufficient degree of frequency, he thought the inductive effect between those two squares ought to be sufficient to work a telephone according to Prof. Tait's calculation. Prof. Tait's calculation was like this—that the telephone was quite sensitive to a current from three Grove cells through the resistance of a wire represented by the distance between this and the sun.

Prof. Thompson said he did not refer to the squares. There was no possible explanation of the experiments from square to square save true induction, but where they had the earth between he believed the far greater part was simply leakage, otherwise conduction, through the earth.

Mr. Traill said that in the remarks Prof. Thompson had made about the electric tramway in Ireland he had no doubt that that gentleman referred to the Newry and Bessbrook electric tramway. He (the speaker) could cite another case—namely, that of the Giants Causeway tramway, where they ran for six miles alongside the Post Office telegraph wire, which was distant only 28ft. from the conductor rail of the tramway, and where there were very great variations in the current of the conductor rail, which was worked with heavy potentials, and yet during the few years that they had been working with the Post Office wire alongside of them, they had never had a single complaint of interference with the messages on the part of the Post Office. He mentioned this as

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an example where induced action did not take place to any appreciable extent upon a telegraph or telephone wire. With judicious forethought the Post Office, when the tramway company he referred to went to Parliament for their Act, put upon them very great restrictions with regard to the electric conductor rail—so much so, in fact, that if those restrictions had been carried out the company would have been put off the road altogether. But when the facts were put before the Post Office authorities, their original stipulations were altered, and the company received permission to run within a certain distance of the telegraph wire, provided their large current would not affect the transmission of messages, which it did not appear to have done.

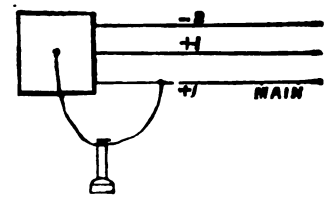
Prof. POYNTING wished to ask whether it would not be possible to arrange a circuit so as to decide between induction and return earth currents?

Mr. PREECE, in reply, desired to disabuse everybody's mind of any idea that there was the slightest chance of secrecy not being maintained. There was a possibility, perhaps, on a Sunday morning, when only one message, say, was being sent from Birmingham to London, and within a region covered with miles of wire, of reading what was going on. But it must not be forgotten that their safety lay in the multitude of messages that were sent, the results being that there was produced on the telephones an incessant patter like that of rain against a window pane. Moreover, it was only possible to read Morse signals on a line that was worked with a single current with dots and dashes. He had explained in Section G that they were going to introduce Delany's multiplex system, which would remove the slightest chance of overhearing anything that might be passing. The cure for these disturbances between telegraphs and telephones was as simple as possible, namely, to invariably use a metallic circuit. Why telephone companies had been so foolish as to exercise the false economy of depending upon single wires was one of those puzzling things which were not possible of explanation. In the Post Office, as soon as they were perfectly satisfied that induction was the main cause of the disturbances, they decided to use double wires, and they never used anything else anywhere. He agreed with Prof. Thompson's remarks. He did not say that the effects he had described were absolutely due to induction, because there were so many things to be taken into consideration. But he had determined to pursue the investigation in a way similar to that which had been suggested by Prof. Poynting between London and the Welsh coast. He would use metallic circuits everywhere, and thrash the question out, for it was really a very important one, for few people had any idea that inductive effects could extend to such an enormous distance.

ON AN EXPERIMENT SHOWING THAT A DIVIDED ELECTRIC CURRENT MAY BE GREATER IN BOTH BRANCHES THAN IN THE MAIN.*

BY LORD RAYLEIGH.

The experiment here described is one that I need not say much about. It has, perhaps, a paradoxical title, and I thought that in that way I might bring out the points really involved in it. The question is, How do conductors in multiple arc or parallel behave when subjected to alternating or periodic currents? The paradox is involved, I think, in the silent introduction of the idea that the currents are steady. If the currents are intermittent, then there is no reason for supposing that the current in the main is the arithmetical sum of the currents in the branches. It must be the alegraic sum under all circumstances. The question of the behaviour of two conductors in parallel, of course, is a very easy one if we suppose that the currents are steady. We then have the law, familiar to electricians, of a division of the current between the two in proportion to their conductivities. But if the currents are alternating, and if the conductors placed in parallel have the property of self-induction which they must have in some degree, and still more if they have a sensible mutual induction one upon the other, then the case becomes a great deal more complicated. In a paper that I published a few months ago in the *Philosophical Magazine* I gave a general calculation of what the resultant resistance of the two conductors placed in parallel to alternating currents would be, and what the resultant self-induction of the two would be—that is to say, I gave what would be the self-induction of any single conductor. In examining that closely I saw what looked to be very curious things involved in it, and which would be brought out, supposing that the two currents placed in parallel were composed of wires laid side by side so as to travel very nearly along the same course, and that will best explain what I have to say. Suppose, too, that you have three wires laid side by side together, and made into a coil of a considerable number of convolutions; and suppose that you have two of those wires in series and combined in such a fashion that the current will circulate in the same way round both those in series, and take that as one of the conductors in parallel, and as the other conductor in parallel take the third wire, and then submit the system composed of those three wires forming two conductors in parallel to alternating currents, what will be the condition of the currents between the two conductors, and how will they be related to the current in the main? The theory shows that when the rapidity of alternation is sufficiently great the endeavour is, as it were, to cause the magnetic effect of the combined currents to be as small as possible at points which they influence—in fact, to neutralise as far as possible magnetic effects; and that tendency more and more asserts itself as the rate of alternation increases, so that ultimately the distribution of the current comes to be independent almost completely of resistance, and to depend solely upon the inductive coefficients. In this case the energy of the field of magnetisation at various points not in the immediate neighbourhood of the three wires may be a suitable index of the distribution of the current neutralised, because we have only to suppose that the current of the two wires joined in series is just half of that, and in the opposite direction to that in the single wire, in order to have at all points complete neutralisation of effect. So that under the influence of rapid periodic currents that is the state of things. You see what is involved in that, namely, that the current in one conductor—in the two wires placed in series—should be represented by +1, the current in the single wire by −2, and the current in the main would be represented by +1, numerically less than one of the currents



in the branches. That is the easiest form in which to make the experiment. I had a large coil, triply wound, and I tried the experiment in the form in which I have related it, in order to estimate the currents in the three conductors. There was a piece of copper sheeting fastened on to a board, three German silver wires of the same diameter were led from it. This was the main [indicating it] coming in along here, and the two branches here, so that if what I say is correct there ought to be along the main a current represented by +1, and along this one a current represented by −2. The current was tested by a sort of telephonic process. Another wire, soldered to this copper sheeting, went to one pole of the telephone, and at the other pole of the telephone the German silver wires were connected by touching the wires at the second telephone terminal at equal distances, and if the currents had been equal in these three wires then of course by touching the second telephone terminal the sounds would have appeared equal. It was found at once that the current of this wire—one of the branches—was very much louder than the current in the other branch, and more than equal to that in the main. In these investigations perhaps it would not do to trust to oneself, but by putting an assistant at the telephone and trying various places it is possible to feel out the points which give the quality of sound, and so to get a numerical estimate of the current in this way. I was not quite satisfied with that. You see in my title I have said "greater in both branches." I have arranged something else, but the principle of it is the same. It involves iron, and it is most easily understood by having five wires instead of three. I combined them, so that three are in series and two are in series, but the three in series are to be combined in parallel with the other two in series, so that in that way, in order to get neutralisation of magnetic effect at a distance, it is necessary that the currents in the two branches in parallel—that the corresponding currents must be in the opposite proportions taken negatively. The currents

* Paper read before the British Association at Birmingham.

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must be in the proportion of +2 −3. Perhaps it would be better to make it +3 −2. Consequently both currents are numerically greater than the current in the main, which is +1. I have verified that sufficiently to show that there is no difficulty whatever in so arranging the thing that the currents in both branches are decidedly greater than that in the main. Perhaps I ought to say that, if anybody wishes to repeat the experiment it is a very easy one indeed if you have a suitable coil. I used a scraping contact only, which is sufficient for the purpose. There were certain perceptible differences by varying the lengths of the wires, but they are not such as to interfere with the experiment.

THE NATIONAL ELECTRIC LIGHT ASSOCIATION OF THE UNITED STATES.

The fourth biennial meeting of this association has just been held at Detroit; there was a large attendance of members, and the subjects discussed were of an eminently practical character. Indeed, from the tone both of the papers and the discussions, it is clear that the American electricians are too full of business at present to care very much for any merely theoretical considerations. For the English reader there is a freshness and vigour and general go-aheadness about these proceedings which, although decidedly less dignified than those of our own technical societies, has such a refreshing tone of confidence and self-reliance that one is inclined to condone the general absence of scientific terminology, and even to overlook the intrusion of a good deal of slang and a certain amount of "bunkum." Unfortunately, however, in the abstracts which exigences of space will alone permit us to give, we fear that a good deal of the native flavour will necessarily be boiled out.

Among the most interesting papers was the following, from which we have only cut out a little philosophising as to the bearing of the subject upon the dawn of the millennium.

The Operation of Motors from Electric Light and Power Stations.

BY MR. T. C. MARTIN.

When I find that more than one hundred electric light companies have the words "and power" in their titles, I come to the conclusion that they mean something by it, and the drift of the paper I had the honour to present, as a proxy, before the association last February on motors, was that it is worth the while of electric light men to pay attention to the questions involved in the distribution of power electrically. The "faith" exhibited by a high-sounding corporate name can be profitably seconded by "works." Electric light men, for the reason that they, more than any others, are familiar with the modern problems of heavy electrical engineering, are the best qualified to introduce electric motors to public notice, and the further I investigate this subject the more deeply do I become convinced that there is hardly a locality where an electric light plant exists in which also electric motors cannot be installed remuneratively.

At the present time, the feeling with regard to motors is in many quarters so sanguine that it amounts to a "boom." Now "booms" are just as bad in their way as inflation of the currency, or any abnormal display of high spirits and strong imagination. But in the case of electric motors, the "boom," if there be one, has been slightly delayed. Historically, the electric motor anticipates in practice the electric telegraph, the electric light, the telephone, and the storage battery, yet to-day it has less importance than any of these, except possibly the last. I venture the opinion that in the near future the relative prominence of these applications will be somewhat changed. Perhaps it is well that the greater perfection of the electric motor has been delayed, and even to-day is tardy. Its ultimate success has depended upon improvements in primary batteries, in secondary batteries, in dynamos, steam engines, boilers and furnaces burning cheap fuel, upon improvements in wires and in line construction, upon the development of modern ideas of urban convenience, and in no small degree upon the multiplication of small industries requiring power minutely subdivided, yet like the Eastern genii, ready at beck and call.

At the present time, the application of the electric motor divides itself into two departments, both of interest to electric light men, that of street railways and that of industrial work. A brief glance may be taken at each department separately, and first at that of street railways. As nearly as I can estimate, over a million passengers have already been hauled by electric locomotives in America, while the number in Europe far exceeds that. Such a fact is significant in itself in these days of rapid change of system and greater attention to comfort in travel. The Baltimore Daft Electric Street Railway, over which many of you travelled in heavy slush and rain last February, is now in its second year of operation, without any electrician in charge, and contemplating an extension. The cost of electric power per day is $12, as compared with $18 for horses under the old system; and the cost per passenger last year was ·83 cent, or about half, as compared with 1·55 cent in 1884.

The Daft system is in use at Revere Beach, Mass., and is now being introduced on the street car lines at Los Angeles, Cal., and elsewhere. The Van Depeole system of electric locomotion is in use in or under contract for several cities, among which may be named Minneapolis, Montgomery, Ala.; Windsor, Ont.; Detroit; Scranton, Pa.; and Appleton, Wis. The figures will, I hope, be presented by Mr. Van Depeole himself, showing results of great economy as compared with mule or horse-power traction. In Philadelphia, Mr. H. M. Schlesinger has a good system operating on a half-mile track, and one that will be introduced at more than one point early next year. The Bentley-Knight system that was successfully tried in Cleveland last year, can now be seen in operation at the Providence Locomotive Works, Rhode Island. And last, though very far from least, is the system of Mr. Frank J. Sprague, who has worked out his inventions and plans with a thoroughness and ingenuity that must awaken admiration in every one. I am not at liberty just now to explain the details of the system; they will probably be made public in a short time. Prof. Henry Rowland has expressed a highly favourable opinion of this system. I should add that Mr. Daft is also resuming his work, with heavier motors, on the New York elevated roads.

The second department in which motors are being used to-day is the industrial, although, even already, the industrial work is subdividing itself. The number of small electric motors in use to-day industrially in this country may be put at certainly far beyond 5,000. Of the old familiar Griscom motor, several hundreds have been put in use; of the Stockwell motor, about 1,000 have already been called for; Daft motors are in use in New York, Boston, Worcester, Providence, Coney Island, and other places. Sprague motors are running in New York, Chicago, Boston, Pittsburgh, Des Moines, Elgin, Oskaloosa, Shamokin, York, New Brunswick, Fall River, New Bedford, Milford, Taunton and Lawrence, Mass., and there are also a great many Brush, Baxter, Pendleton, Bergmann, Keegan, Edgerton, Reckenzaun, Ayrton and Perry, Diehl, Roberts, Crocker and Curtis, and other motors in use all over the country, on work of the most varying nature. A few exemplifications of their use by electric light companies will perhaps be interesting. In Philadelphia the Brush Company is running about 250 Stockwell motors and one 1 horse-power motor. The small motors are chiefly on factory sewing machines, but some are on fans and jewellers' lathes. They are generally giving satisfaction, and if the company could only get its wires to the places wanting motors, the number in use would be quadrupled. Mr. M. D. Law, the electrician of the company, who has charge of this department, operates 18 of the small motors with the power required for one arc light, if they all of them run together at one time; but in practice he has no trouble in running from 30 to 40 with the same power, as they are never all on together. The charge for the current is $5 per month for the first four motors and then $1 per month for each additional motor. All motors are wisely sold outright, the company only renting the current for them. At the Brush-Swan Station, Cheyenne, Wyoming, Mr. E. P. Roberts is building his own motors and finding a wide variety of use for them. One runs an evening paper, another a gunsmith's lathe and emery grinder, and two others cut up sausage meat for butchers. In the case of the gunsmith, the charge is ten cents per hour per horse-power. The motors are run from Brush storage batteries on the day incandescent circuit, and at night from the dynamo, the potential being 100 volts. The Brush station at Baltimore has been putting out motors, chiefly of the Baxter and Edgerton types, quite extensively. The Baxter motor there has been running on a great variety of work, on arc circuits, with good profit, and is said to be very economical of power while regulating with the utmost closeness under all variations of load.

At Des Moines, Ia., the local Edison Company is running a number of Sprague motors. One of these motors, of three horse-power, is used in a livery stable to run the elevator for hoisting the buggies and hay, for pumping water, and brushing down the horses. One runs a scissors grinder's outfit, one a drug mill, one a polisher in a plating establishment, and, curiously, one the generator in the Telephone Exchange. Several elevators now run by water will have electromotors this fall. Mr. F. H. Whiting, the manager, says:—"I think that the motors in reasonably large towns can be made to go a long way to the paying of running expenses of those stations that have to run all the time, as in the incandescent business."

At New Bedford, Mass., seven Sprague motors have already been installed within a short time by the local Edison Company, and are now used in silver-plating works, on ice cream freezers, on coffee grinders, bookbinders' cutting presses, on a hydro-extractor in dye works, and on a hair-picking machine. These motors earn easily altogether about $40 a month, on the regular incandescent circuit, the current being supplied at lamp rates, 1¼ cent. per 16 candle-power per lamp hour, and measured by meter.

In Boston, the Sprague Company is running a large motor service on a circuit embracing a three-quarter mile radius from its station in Bumstead-court, the motors ranging in capacity from ½ horse-power to 1½ horse-power. The motors are sold outright to the customers, and $125 per horse-power per annum is charged for the current or power service. The intermittent use by the consumer is found to be an important factor in supplying power, as not more than 37 per cent. of that sold is ever called for at one time, so that, allowing for the loss in transmission, at least double the engine service can be sold, provided the power is distributed in small quantities. From actual tests made by one company it appears that some few of the averages of power consumed run as low as 14 and 15 per cent., and Mr. Sprague tells me that the higher average of from 33 to 37 per cent. will apply not only to small powers, but is absolutely true of large powers, such as 40, 50, or 100 horse, where a number of these are operating together from a central station.

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As an evidence of the feeling in Boston on the subject of motors, I may mention that the Merchants' Electric Light and Power Company, running 800 Thomson-Houston arc lamps, has voted to adopt, and is now equipping for, the Sprague system. At Springfield, Mass., another actual electric power station will be established. The Springfield Steam Power Company, heretofore transmitting power by belting, shafting, and wire cables, has now decided to distribute power by means of electric current, as giving a better and more economical service, as well as increasing the distance at which it can work. The change is being carried out at the present hour.

In New York a great many Sprague motors are in use. A large number of Daft motors have been in operation there for a considerable length of time, and I know from actual personal inquiry and observation that you could not get these customers to abandon the use of their motors. One instance deserves special mention. Mr. E. B. Stimpson, in Spruce-street, well-known as an inventor and manufacturer of fine machinery for the shoe and stationery trades, has for about a year been running four floors of his workshop with a Daft motor. Some of the machines belted to the shafting on the various floors are quite heavy—drills, lathes, planers, and the like; others are extremely fine and delicate; but for all of them, Mr. Stimpson tells me, the electric power has been sufficiently steady. He had formerly a 10 horse-power vertical engine, with boiler on the top floor of his building, and had the usual trouble with engineers, coal, ashes, dust, oil, vibration and great heat in summer. Now, in striking contrast, a little 6 horse-power Daft motor stands on a small wooden base, close up against the disused boiler and engine, making so slight a noise that it in no way interrupts conversation. The motor runs the day through, and all the attention it gets is a very occasional visit and wipe on the commutator from a motor man, who also has charge of a number of other motors all round the neighbourhood. Mr. Stimpson pays $12 a week, and I doubt if there is a manufacturer in New York to-day better pleased with his power than is Mr. Stimpson with the electric motor he has been using so long and with such good results.

A great many motors to day are operating very successfully with primary batteries, and that field will grow.

In the incandescent business, the plant must be kept running all the time, so that the consumer can always have his light when he wants it. Hence I look upon motors as the most important auxiliary to-day for incandescent lighting, and I think that in many an arc station, too, they will solve the financial problems of day lighting. But whether that be so or not, what I have said shows, I think, that the day of the electric motor is upon us.

A discussion followed the reading of this paper, to which we hope to refer in a subsequent issue.

"ANTI-INDUCTION" TELEPHONE CABLES.

The telephone cables which are manufactured by Messrs. Felten and Guilleaume, at Mulheim-on-the-Rhine, under the name of "anti-induction" cables, have lately come into somewhat extensive use, and their performance seems to give much satisfaction.

The cables are manufactured in one continuous piece of any required length, and are made up with any required number of wires. The standard sizes contain twenty-seven and fifty-two wires respectively. The diameter of the conductors is varied according to the length of the line for which they are intended. For the greatest distances hitherto attempted No. 19 B.W.G. is employed, and for shorter distances either No. 21 or No. 22. Each wire is separately insulated by a "special impregnated fibre," of which further particulars are not at present forthcoming.

The whole cable is enclosed in a sheathing of lead, which is finally served with tape. It is claimed that the impregnated fibre possesses a high insulating power, that its mechanical properties are good, and that it is unaffected either by atmospheric influences or by changes of temperature, so that the cables are equally well adapted for overhead or for underground use. When placed underground, it is also claimed that, owing to the above-described properties, they may be laid in shallower trenches and require less external protection than gutta percha or india rubber covered lines, so that, if desired, they can be placed immediately under the paving stones of the side walks, where additions or repairs are most easily undertaken. An iron trough 4½in. by 7in. will contain 24 of these cables, each of 27 conductors, or in all 648 wires.

The difficulties connected with induction are overcome by wrapping each insulated wire with a separate layer or coating of tinfoil. This may not be a theoretically perfect method, but in practice it has stood the test of actual work under the most unfavourable conditions, and with very excellent results. To lesson the danger of leakage from wire to wire, each cable also contains a certain number of idle wires, which may be connected to earth at either end. The conductors may, of course, be used either with earth or with metallic returns, or by means of induction coils the two systems may, under certain circumstances, be advantageously combined.

In the case of trunk lines from town to town, for instance, it is frequently useful and economial to employ underground cables with either metallic or earth circuits through the streets, and then to connect with aerial wires having earth returns over the intervening country. It is well known that such a circuit is in general peculiarly liable to inductional disturbance, but the method has been found to answer remarkably well with the Felten-Guilleaume cables. A circuit consisting of two overhead sections and one underground section is in use between Liverpool and Birkenhead, where one of these cables, a mile and a half in length, containing twenty-seven conductors, passes through the Mersey Tunnel. Telephonic circuits of a similar character are in use in Berlin, Munich, Nuremberg, Stuttgard, Copenhagen, Christiana, Bergen, Montreal, and Buenos Ayres. At Copenhagen 13 miles of these cables have been laid, of which 10 miles are underground. Inductive effects are not altogether absent in this case, but they have practically no injurious effect upon the articulation. In this exchange all the electro-magnetic annunciators are provided with shunts, so as to avoid the injurious effects of the self-induction of the soft iron cores of the magnets. This is found to be a very great improvement, a result which recent developments of theory have fully prognosticated. In all cases where electro-magnetic annunciators have to remain in the speaking circuit a similar arrangement ought undoubtedly to be provided. It would be a still further improvement if the shunt coils were wound non-inductively, and of course they must have a resistance sufficiently high to allow the annunciators to be worked by the magneto or battery current.

At Copenhagen the shunt coils are made with about four times the resistance of the annunciator coils, and from figures which have recently been published in this journal it is easy to understand that in this case the "virtual" resistance of the annunciator coil may, for the higher tones, be many hundred times as great as that of the shunt coil, so that by the insertion of the shunt, overtones which are essential to distinct articulation and which would otherwise be practically extinguished, are transmitted with comparatively little loss. Messrs. Felten and Guilleaume have recently carried out an extensive series of experiments at their works which still further illustrate the same point. In one case a line was employed consisting of 30 miles of open wire and four miles of cable. The cable was lead cased, the conductors had each a resistance of 39 ohms per mile, insulation resistance 8,000 megohms, with a capacity of 29 microfarads per mile at 0°C. Under these conditions the articulation was perfectly clear and distinct, and little or no difference could be detected whether the four miles of cable were or were not included in the circuit, *but directly an ordinary annunciator was inserted, a very marked deterioration was apparent*, or, to speak more correctly, we should say, was audible.

In some further experiments of a similar character, with a copper resistance of 24 ohms per mile, but with the insulation resistance diminished to 1,500 megohms, the volume of sound was perceptibly diminished when more than two and-a-quarter miles of cable were in circuit, thus showing that high insulation resistance is by no means to be overlooked in telephone work of this description.

Experiments upon the inductive effects between adjacent wires showed that upon lengths of cable of three kilometres and upwards the wires nearest to the one in use suffered a certain amount of inductive effect, but up to six kilometres, which seems to have been as far as the experiment was carried, the conversation could not in any case be overheard. In conclusion, we may add that these cables are not expensive, and from the foregoing description it will be evident that they form a valuable addition to the resources of telephony, especially where large numbers of wires follow the same route.

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CHEMISTRY AS A SCIENCE.*

A glance over the Presidential Addresses delivered before this section on former occasions will show that the occupiers of this chair have ranged over a fairly wide field. Some of my predecessors have given a general survey of the progress of chemical science during the past year, some, taking up a technological aspect of the subject, have discussed the bearings of chemistry upon our national industries; others, again, have passed in review the various institutions in this country for teaching chemistry; and in yet other cases the speaker has had the opportunity of bringing before the scientific world, for the first time, an account of some important original researches.

On this occasion I venture to ask your attention to a few thoughts on the very foundations of chemistry as a science—on the nature and the probable, or at least possible, origin of the so called elements. If the views to which I have been led may at first glance appear heretical, I must remind you that in some respects they are shared more or less, as I shall subsequently show, by not a few of the most eminent authorities, and notably by one of my predecessors in this chair, Dr. J. H. Gladstone, F.R.S., to whose brilliant address, delivered in 1883, I must beg to refer you.

Should it not sometimes strike us, chemists of the present day, that after all we are in a position unpleasantly akin to that of our forerunners, the alchemists of the Middle Ages? These necromancers of a time long past did not, indeed, draw so sharp a line as do we between bodies simple and compound; yet their life-task was devoted to the formation of new combinations, and to the attempt to transmute bodies which we commonly consider as simple and ultimate—that is, the metals. In the department of synthesis they achieved very considerable successes; in the transmutation of metals their failure is a matter of history.

But what are we of this so-called nineteenth century doing in our laboratories and our libraries? Too many of us are content to acquire simply what others have already observed and discovered, with an eye directed mainly to medals, certificates, diplomas, and other honours recognised as the fruits of "passing." Others are seeking to turn the determined facts of chemistry to useful purposes; whilst a third class, sometimes not easily distinguished from the second, are daily educing novel organic compounds, or are racking their ingenuity to prepare artificially some product which Nature has hitherto furnished us through the instrumentality of plants and animals. The practical importance of such investigations, and their bearing on the industrial arts and on the purposes and needs of daily life, have been signally manifested during the last half-century.

Still a fourth class of inquirers, working at the very confines of our knowledge, find themselves, occasionally at least, face to face with a barrier which has hitherto proved impassable, but which must be overthrown, surmounted, or turned, if chemical science is ever to develop into a definite, an organised unity. This barrier is nothing less than the chemical elements commonly so called, the bodies as yet undecomposed into anything simpler than themselves. There they extend before us, as stretched the wide Atlantic before the gaze of Columbus, mocking, taunting, and murmuring strange riddles, which no man yet has been able to solve.

The first riddle, then, which we encounter in chemistry is, "What are the elements?" Of the attempts hitherto made to define or explain an element none satisfy the demands of the human intellect. The text-books tell us that an element is "a body which has not been decomposed"; that it is "a something to which we can add, but from which we can take away nothing," or "a body which increases in weight with every chemical change." Such definitions are doubly unsatisfactory; they are provisional, and may cease to-morrow to be applicable in any given case. They take their stand, not on any attribute of the things to be defined, but on the limitations of human power; they are confessions of intellectual impotence.

Just as to Columbus long philosophic meditation led him to the fixed belief of the existence of a yet untrodden world beyond that waste of Atlantic waters, so to our most keen eyed chemists, physicists, and philosophers a variety of phenomena suggest the conviction that the elements of ordinary assumption are not the ultimate boundary in this direction of the knowledge which man may hope to attain. Well do I remember, soon after I had obtained evidence of the distinct nature of thallium, that Faraday said to me, "To discover a new element is a very fine thing, but if you could decompose an element and tell us what it is made of, that would be a discovery indeed worth making." And this was no new speculation of Faraday's, for in one of his early lectures he remarked, "At present we begin to feel impatient, and to wish for a new state of chemical elements. For a time the desire was to add to the metals, now we wish to diminish their number. . . . To decompose the metals, then to reform them, to change them from one to another, and to realise the once absurd notion of transmutation, are the problems now given to the chemist for solution."

Mr. Herbert Spencer, in his hypothesis of the constitution of matter, says:—"All material substances are divisible into so-called elementary substances composed of molecular particles of the same nature as themselves; but these molecular particles are complicated structures consisting of congregations of truly elementary atoms, identical in nature and differing only in position, arrangement, motion, &c., and the molecules or chemcal atoms are produced from the true or physical atoms by processes of evolution under conditions which chemistry has not yet been able to reproduce."

Mr. Norman Lockyer has shown, I think on good evidence, that, in the heavenly bodies of the highest temperature, a large number of our reputed elements are dissociated, or, as it would perhaps be better to say, have never been formed. Mr. Lockyer holds that "the temperature of the sun and the electric arc is high enough to dissociate some of the so-called chemical elements, and give us a glimpse of the spectra of their bases;" and he likewise says that "a terrestrial element is an exceedingly complicated thing that is broken up into simpler things at the temperature of the sun, and some of these things exist in some sun-spots, while other constituents exist in others."

The late Sir Benjamin Brodie, in a lecture on Ideal Chemistry delivered before the Chemical Society in 1867, goes even further than this. He says:—"We may conceive that, in remote time or in remote space, there did exist formerly, or possibly do exist now, certain simpler forms of matter than we find on the surface of our globe—a, χ, ξ, ν, and so on. . . . We may consider that in remote ages the temperature of matter was much higher than it is now, and that these other things existed then in the state of perfect gases—separate existences—uncombined. . . . We may then conceive that the temperature began to fall, and these things to combine with one another and to enter into new forms of of existence, appropriate to the circumstances in which they were placed. . . . We may further consider that, as the temperature went on falling, certain forms of matter became more permanent and more stable, to the exclusion of other forms. . . . We may conceive of this process of the lowering of the temperature going on, so that these substances, when once formed, could never be decomposed—in fact, that the resolution of these bodies into their component elements could never occur again. You would then have something of our present system of things. . . .

"Now this is not purely an imagination, for when we look upon the surface of our globe we have actual evidence of similar changes in Nature. . . . When we look at some of the facts which have been revealed to us by the extraordinary analyses which have been made of the matter of distant worlds and nebulæ, by means of the spectroscope, it does not seem incredible to me that there may even be evidence, some day, of the independent existence of such things as χ and ν."

In his Burnett lectures "On Light as a Means of Investigation," Prof. Stokes, speaking of a line in the spectrum of the nebulæ, says:—"It may possibly indicate some form of matter more elementary than we know on earth. There seems no *à priori* improbability in such a supposition so great as to lead us at once to reject it. Chemists have long speculated on the so-called elements, or many of them, being merely very stable compounds of elements of a higher order, or even perhaps of a single kind of matter."

In 1868 Graham wrote of Sir W. Thomson's vortex-ring theory, as enlivening "matter into an individual existence and constituting it a distinct substance or element."

From these passages, which might easily be multiplied, it plainly appears that the notion—not necessarily of the decomposability, but at any rate of the complexity of our supposed elements—is, so to speak, in the air of science, waiting to take a further and more definite development. It is important to keep before men's minds the idea of the genesis of the elements; this gives some form to our conceptions, and accustoms the mind to look for some physical production of atoms. It is still more important, too, to keep in view the great probability that there exist in Nature laboratories where atoms are formed and laboratories where atoms cease to be. We are on the track and are not daunted, and fain would we enter the mysterious region which ignorance tickets "Unknown." It is for us to strive to unravel the secret composition even of the so-called elements—to undauntedly persevere—and "still bear up right onward."

If we adopt the easy-going assumption that the elements, whether self-existent or created, are absolutely and primordially distinct; that they existed as we now find them prior to the origin of stars and their attendant planets, constituting, in fact, the primal "fire-mist," we are little, if any, the wiser. We look at their number and at their distinctive properties, and we ask, Are all these points accidental or determinate? In other words, might there as well have been only 7, or 700, or 7,000 absolutely distinct elements as the 70 (in round numbers) which we now commonly recognise? The number of the elements does not, indeed, commend itself to our reason from any *à priori* or extraneous considerations. Might their properties have conceivably differed from those which we actually observe? Are they formed by a "fortuitous concatenation," or do they constitute together a definite whole, in which each has its proper part to play, and from which none could be extruded without leaving a recognisable deficiency?

If their peculiarities were accidental it would scarcely be possible for the elements to display those mutual relations which we find brought into such prominent light and order in the periodic classification of Newlands, Mendeleeff, and Meyer. Has not the relation between the atomic weights of the three halogens, chlorine, bromine, and iodine, and their serially varying properties, physical and chemical, been worn nearly threadbare? And the same with the calcium and the sulphur groups? Surely probability of such relations existing among some 70 bodies which had come into fortuitous existence would prove to be vanishingly small.

We ask whether these elements may not have been evolved from some few antecedent forms of matter—or possibly from only one such—just as it is now held that all the innumerable variations of plants and animals have been developed from fewer and earlier forms of organic life? As Dr. Gladstone well puts it, "they have been built up one from another, according to some general plan." This building up, or evolution, is above all things not fortuitous: The variation and development which we recognise in the universe run along certain fixed lines which have been preconceived and foreordained. To the careless and hasty eye design and evolution seem antagonistic; the more careful inquirer sees that evolution, steadily proceeding along an ascending scale of excellence, is the strongest argument in favour of a preconceived plan.

The array of the elements cannot fail to remind us of the general aspect of the organic world. In both cases we see certain groups well filled up, even crowded with forms having among themselves but little specific

* Prof. Crookes's Address to the Mechanical Science Section of the British Association, September, 1886.

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difference. On the other hand, in both, other forms stand widely isolated. Both display species that are common and species that are rare; both have groups widely distributed—it might be said cosmopolitan—and other groups of very restricted occurrence. Among animals I may mention as instances the Monotremata of Australia and New Guinea, and among the elements the metals of the so-called rare earths.

Now, as these facts in the distribution of organic forms are generally considered by biological experts to rank among the weightiest evidences in favour of the origin of species by a process of evolution, it seems natural, in this case as in the other, to view existing elements not as primordial, but as the gradual outcome of a process of development, possibly even of a "struggle for existence." Bodies not in harmony with the present general conditions have disappeared, or perhaps have never existed. Others—the asteroids among the elements—have come into being, and have survived, but only on a limited scale; whilst a third class are abundant because surrounding conditions have been favourable to their formation and preservation.

The analogy here suggested between elements and organism is, indeed, not the closest, and must not be pushed too far. From the nature of the case there cannot occur in the elements a difference corresponding to the difference between living and fossil organic forms. The "great stone book" can te'l us nothing of extinct elements. Nor would I for a moment suggest that any one of our present elements, however rare, is like a rare animal or plant in process of extinction; that any new element is in the course of formation; or that the properties of existing element are gradually undergoing modification. All such charges must have been confined to that period so remote as not to be grasped by the imagination, when our Earth, or rather the matter of which it consists, was in a state very different from its present condition. The epoch of elemental development is decidedly over, and I may observe that in the opinion of not a few biologists the epoch of organic development is verging upon its close.

Making, however, every allowance for these distinctions, if evolution be a cosmic law, manifest in heavenly bodies, in organic individuals, and in organic species, we shall in all probability recognise it, though under especial aspects, in those elements of which stars and organisms are in the last resort composed.

Is there, then, in the first place, any direct evidence of the transmutation of any supposed "element" of our existing list into another, or of its resolution into anything simpler?

To this question I am obliged to reply in the negative.

I doubt whether any chemist here present could suggest a process which would hold out a reasonable prospect of dissocating any of our accepted simple bodies. The highest temperatures and the most powerful electric currents at our disposal have been tried, and tried in vain. At one time there seemed a possibility at least that the interesting researches of Prof. Victor Meyer might show the two higher members of the halogen group, bromine and iodine, as entering upon the path of dissociation. These hopes have not been fulfilled. It may be said, in the general opinion of the most eminent and judicious chemists, that none of the phenomena thus elicited prove that even an approach has been made to the object in view.

Even if we leave our artificial laboratories and seek an escape from the difficulty by observing the processes of the great laboratories of Nature, we feel no sufficiently firm ground.

We find ourselves thus driven to indirect evidence—to that which we may glean from the mutual relations of the elementary bodies. Such evidence of great value is by no means lacking, and to this I now beg to direct attention. First, we may consider the conclusion arrived at by Herschel, and pursued by Clerk-Maxwell, that atoms bear the impress of manufactured articles. Let us look a little more closely at this view. A manufactured article may well be supposed to involve a manufacturer. But it does something more; it implies certainly a raw material, and probably, though not certainly, the existence of by-products, residues, paraleipomena. What or where is here the raw material? Can we detect any form of matter which bears to the chemical elements a relation like that of a raw material to the finished product, like that, say, of coal-tar to alizarin? Or can we recognise any elementary bodies which seem like waste or refuse? Or are all the elements, according to the common view, coequals? To these questions no direct answers is as yet forthcoming.

And this leads us up to a hypothesis which, if capable of full demonstration, would show us that the accepted elements are not coequal, but have been formed by a process of expansion or evolution. I refer to the well-known hypothesis of Prout, which regards the atomic weights of the elements as multiples, by a series of whole numbers, of unity = the atomic weight of hydrogen. Everyone is aware that the recent more accurate determinations of the atomic weights of different elements do not by any means bring them into close harmony with the values which Prout's law would require. Still, in no small number of cases the actual atomic weights approach so closely to those which the hypothesis demands that we can scarcely regard the coincidence as accidental. Accordingly, not a few chemists of admitted eminence consider that we have here an expression of the truth, masked by some residual or collateral phenomena which we have not yet succeeded in eliminating.

The original calculations on which the most accurate numbers for the atomic weights are founded have recently been recalculated by Mr. F. W. Clarke. In his concluding remarks, speaking of Prout's law, Mr. Clarke says that "none of the seeming exceptions are inexplicable. In short, admitting half multiples as legitimate, it is more probable that the few apparent exceptions are due to undetected constant errors than that the great number of close agreements should be merely accidental. I began this recalculation of the atomic weights with a strong prejudice against Prout's hypothesis, but the facts as they came before me have forced me to give it a very respectful consideration."

(To be continued.)

THE BRITISH ASSOCIATION MEETING.

PRESIDENTIAL ADDRESS.

(Continued from page 396.)

The warm water thrown into the North Atlantic not only increases the temperature of its whole waters, but gives an exceptionally mild climate to Western Europe. Still the countervailing influence of the Arctic currents and the Greenland ice is sufficient to permit icebergs which creep down to the mouth of the Strait of Belle Isle, in the latitude of the south of England, to remain unmelted till the snows of a succeeding winter fall upon them. Now let us suppose that a subsidence of land in tropical America were to allow the equatorial current to pass through into the Pacific. The effect would at once be to reduce the temperature of Norway and Britain to that of Greenland and Labrador at present, while the latter countries would themselves become colder. The northern ice, drifting down into the Atlantic, would not, as now, be melted rapidly by the warm water which it meets in the Gulf Stream. Much larger quantities of it would remain undissolved in summer, and thus an accumulation of permanent ice would take place, along the American coast at first, but probably at length even on the European side. This would still further chill the atmosphere, glaciers would be established on all the mountains of temperate Europe and America,* the summer would be kept cold by melting ice and snow, and at length all Eastern America and Europe might become uninhabitable, except by Arctic animals and plants, as far south as perhaps 40deg. of north latitude. This would be simply a return of the Glacial age. I have assumed only one geographical change; but other and more complete changes of subsidence and elevation might take place, with effects on climate still more decisive; more especially would this be the case if there were a considerable submergence of the land in temperate latitudes.

We may suppose an opposite case. The high plateau of Greenland might subside or be reduced in height, and the openings of Baffin's Bay and the North Atlantic might be closed. At the same time the interior plain of America might be depressed, so that, as we know to have been the case in the Cretaceous period, the warm waters of the Mexican Gulf would circulate as far north as the basins of the present great American lakes. In these circumstances there would be an immense diminution of the sources of floating ice, and a correspondingly vast increase in the surface of warm water. The effects would be to enable a temperate flora to subsist in Greenland, and to bring all the present temperate regions of Europe and America into a condition of subtropical verdure.

It is only necessary to add that we know that vicissitudes not dissimilar from those above sketched have actually occurred in comparatively recent geological times, to enable us to perceive that we can dispense with all other causes of change of climate, though admitting that some of them may have occupied a secondary place.† This will give us, in dealing with the distribution of life, the great advantage of not being tied up to definite astronomical cycles of glaciation, which may not always suit the geological facts, and of correlating elevation and subsidence of the land with changes of climate affecting living beings. It will, however, be necessary, as Wallace well insists, that we shall hold to that degree of fixity of the continents in their position, notwithstanding the submergences and emergences they have experienced, to which I have already adverted. Sir Charles Lyall, more than forty years ago, published in his "Principles of Geology" two imaginary maps which illustrate the extreme effects of various distribution of land and water. In one all the continental masses are grouped around the equator. In the other they are all placed around the poles, leaving an open equatorial ocean. In the one case the whole of the land and its inhabitants would enjoy a perpetual summer, and scarcely any ice could exist in the sea. In the other the whole of the land would be subjected to an arctic climate, and it would give off immense quantities of ice to cool the ocean. But Lyell did not suppose that any such distribution as that represented in his maps had actually occurred, though this supposition has been sometimes attributed to him. He merely put what he regarded as an extreme case to illustrate what might occur under conditions less exaggerated. Sir Charles, like other thoughtful geologists, was well aware of the general fixity of the areas of the continents, though with great modifications in the matter of submergence and of land conditions. The union, indeed, of these two great principles of fixity and diversity of the continents lies at the foundation of theoretical geology.

We can now more precisely indicate this than was possible when Lyell produced his "Principles," and can reproduce the conditions of our continents in even the more ancient periods of their history. Some examples may be taken from the history of the American continent, which is more simple in its arrangements than the double continent of Europ-Asia. We may select the early Devonian or Erian period, in which the magnificent flora of that age—the earliest certainly known to us—made its appearance. Imagine the whole interior plain of North America submerged, so that the continent is reduced to two strips on the east and west, connected by a belt of Laurentian land on the north. In the great Mediterranean sea thus produced the tepid water of the equatorial current circulated, and it swarmed with corals, of which we know no less than one hundred and fifty species, and with other forms of life appropriate to warm seas. On the islands and coasts of this sea was introduced the Erian flora, appearing first in the north, and with that vitality and colonising power of which, as Hooker has well shown, the Scandinavian

* According to Bonney, the west coast of Wales is about 12deg. above the above the average for its latitude, and if reduced to 12deg. below the average its mountains would have large glaciers.

† More especially the ingenious and elaborate arguments of Croll deserve consideration; and, though I cannot agree with him in his main thesis, I gladly acknowledge the great utility of the work he has done.

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flora is the best modern type, spreading itself to the south.* A very similar distribution of land and water in the Cretaceous age gave a warm and equable climate in those portions of North America not submerged, and coincided with the appearance of the multitude of broad-leaved trees of modern types introduced in the early and middle Cretaceous, and which prepared the way for the mammalian life of the Eocene. We may take a still later instance from the second continental period of the later Pleistocene or early Modern, when there would seem to have been a partial or entire closure of the North Atlantic against the Arctic ice, and wide extensions seaward of the European and American land, with possibly considerable tracts of land in the vicinity of the equator, while the Mediterranean and the Gulf of Mexico were deep inland lakes.† The effect of such conditions on the climates of the northern hemisphere must have been prodigious, and their investigation is rendered all the more interesting because it would seem that this continental period of the post-Glacial age was that in which man made his first acquaintance with the coasts of the Atlantic, and possibly made his way across its waters.

We have in America ancient periods of cold as well as of warmth. I have elsewhere referred to the boulder conglomerates of the Huronian, of the Cambrian and Ordovician, of the Millstone-grit period of the Carboniferous, and of the early Permian; but would not venture to affirm that either of these periods was comparable in its cold with the later Glacial age, still less with that imaginary age of continental glaciation assumed by certain of the more extreme theorists.‡ These ancient conglomerates were probably produced by floating ice, and this at periods when in areas not very remote temperate floras and faunas could flourish. The glacial periods of our old continent occurred in times when the surface of the submerged land was opened up to the northern currents, drifting over it mud and sand and stones, and rendering nugatory, in so far at least as the bottom of the sea was concerned, the effects of the superficial warm streams. Some of these beds are also peculiar to the eastern margin of the continent, and indicate ice-drift along the Atlantic coast in the same manner as at present, while conditions of greater warmth existed in the interior. Even in the more recent Glacial age, while the mountains were covered with snow and the lowlands submerged under a sea laden with ice, there were interior tracts in somewhat high latitudes of America in which hardy forest trees and herbaceous plants flourished abundantly; and these were by no means exceptional "inter-glacial" periods. Thus we can show that while from the remote Huronian period to the Tertiary the American land occupied the same position as at present, and while its changes were merely changes of relative level as compared with the sea, these have so influenced the ocean currents as to cause great vicissitudes of climate.

Without entering on any detailed discussion of that last and greatest Glacial period which is best known to us, and is more immediately connected with the early history of man and the modern animals, it may be proper to make a few general statements bearing on the relative importance of sea-borne and land ice in producing those remarkable phenomena attributable to ice action in this period. In considering this question it must be borne in mind that the greater masses of floating ice are produced at the seaward extremities of land glaciers, and that the heavy field-ice of the Arctic regions is not so much a result of the direct freezing of the surface of the sea as of the accumulation of snow precipitated on the frozen surface. In reasoning on the extent of ice action, and especially of glaciers in the Pleistocene age, it is necessary to keep this fully in view. Now in the formation of glaciers at present—and it would seem also in any conceivable former state of the earth—it is necessary that extensive evaporation should conspire with great condensation of water in the solid form. Such conditions exist in mountainous regions sufficiently near to the sea, as in Greenland, Norway, the Alps, and the Himalayas; but they do not exist in low arctic lands like Siberia or Grinnel-land nor in inland mountains. It follows that land glaciation has narrow limits, and that we cannot assume the possibility of great confluent or continental glaciers covering the interior of wide tracts of land. No imaginable increase of cold could render this possible, inasmuch as there could not be a sufficient influx of vapour to produce the necessary condensation; and the greater the cold the less would be the evaporation. On the other hand, any increase of heat would be felt more rapidly in the thawing and evaporation of land ice and snow than on the surface of the sea.

Applying these very simple geographical truths to the North Atlantic continents, it is easy to perceive that no amount of refrigeration could produce a continental glacier, because there could not be sufficient evaporation and precipitation to afford the necessary snow in the interior. The case of Greenland is often referred to, but this is the case of a high mass of cold land with sea, mostly open, on both sides of it, giving, therefore, the conditions most favourable to precipitation of snow. If Greenland was less elevated, or if there were dry plains around it, the case would be quite different, as Nares has well shown by his observations on the summer verdure of Grinnel-land, which in the immediate vicinity of North Greenland, presents very different conditions as to glaciation and climate.§ If the plains were submerged, and the Arctic currents allowed free access to the interior of the continent of America, it is conceivable that the mountainous regions remaining out of the water would be covered with snow and ice, and there is the best evidence that this actually occurred in the Glacial period; but with the plains out of water this would be impossible. We see evidence of this at the present day in the fact that in unusually cold winters the great precipitation of snow takes place south of Canada, leaving the north comparatively bare, while as the temperature becomes milder the area of snow-deposit moves farther to the north. Thus a greater extension of the Atlantic, and especially of its cold ice-laden arctic currents, becomes the most potent cause of a glacial age.

I have long maintained these conclusions on general geographical grounds, as well as on the evidence afforded by the Pleistocene deposits of Canada; and in an address the theme of which is the ocean I may be excused for continuing to regard the supposed terminal moraines of great continental glaciers as nothing but the southern limit of the ice-drift of a period of submergence. In such a period the southern margin of an ice-laden sea where its floe-ice and bergs grounded, or where its ice was rapidly melted by warmer water, and where consequently its burden of boulders and other *débris* was deposited, would necessarily present the aspect of a moraine, which, by the long continuance of such conditions, might assume gigantic dimensions. Let it be observed, however, that I fully admit the evidence of the great extension of local glaciers in the Pleistocene age, and especially in the times of partial submergence of the land.

I am quite aware that it has been held by many able American geologists* that in North America a continental glacier extended in temperate latitudes from sea to sea, or at least from the Atlantic to the Rocky Mountains, and that this glacier must, in many places, have exceeded a mile in thickness. The reasons above stated appear, however, sufficient to compel us to seek for some other explanation of the observed facts, however difficult this may at first sight appear. With a depression such as we know to have existed, admitting the Arctic currents along the St. Lawrence Valley, through gaps in the Laurentian watershed, and down the great plains between the Laurentian areas and the Rocky Mountains, we can easily understand the covering of the hills of Eastern Canada and New England with ice and snow, and a similar covering of the mountains of the west coast. The sea also in this case might be ice-laden and boulder-bearing as far south as 40°, while there might still be low islands far to the north on which vegetation and animals continued to exist. We should thus have the conditions necessary to explain all the anomalies of the glacial deposits. Even the glaciation of high mountains south of the St. Lawrence Valley would then become explicable by the grounding of floe-ice on the tops of these mountains when reefs in the sea. In like manner we can understand how on the isolated trappean hill of Beloeil, in the St. Lawrence Valley, Laurentian boulders far removed from their native seats to the north are perched at a height of about 1,200ft. on a narrow peak where no glacier could possibly have left them. The so-called moraine, traceable from the great Missouri Coteau in the west, to the coasts of New Jersey, would thus become the mark of the western and southern limit of the subsidence, or of the line along which the cold currents bearing ice were abruptly cut off by warm surface waters. I am glad to find that these considerations are beginning to have weight with European geologists in their explanation of the glacial drift of the great plains of Northern Europe.

Whatever difficulties may attend such a supposition, they are small compared with those attendant on the belief of a continental glacier, moving without the aid of gravity, and depending for its material on the precipitation taking place on the interior plains of a great continent.

(To be continued.)

* As I have elsewhere endeavoured to show ("Report on Silurian and Devonian Plants of Canada"), a warm climate in the Arctic region seems to have afforded the necessary conditions for the great colonising floras of all geological periods. Gray had previously illustrated the same fact in the case of the more modern floras.

† Dawkins, *Popular Science Monthly*, 1873.

‡ "Notes on Post-Pliocene of Canada." Hicks, "Pre-Cambrian Glaciers," *Geol. Mag.*, 1880.

§ These views have been admirably illustrated by Von Wœickoff in the paper already referred to and in previous geographical papers.

COMPANIES' REPORTS.

Direct Spanish Telegraph Company.

Report of the Directors for the half year ended 30th June last, to be presented to the general meeting of shareholders on Thursday, the 30th inst., at 3 o'clock:—

The accounts for the half year show, after providing for debenture interest, a balance to the credit of profit and loss of £4,573. 12s 2d. The traffic receipts show an increase of £1,022. 2s., as compared with the corresponding half year of 1885, and a decrease of £89. 10s. as compared with the last half year. The new Bilbao and the Marseilles-Barcelona cable continue in good working order. The Directors have already, by their circular of 16th July last, advised the shareholders of the result of the examination of the original Bilbao cable, and of the opinion of the firm of engineers, Messrs. Clark, Forde, and Taylor, who superintended the operations, to the effect that this line could not be advantageously restored, and the Board have accordingly abandoned it. They enclose a special report on the financial steps which are requisite to be taken in consequence of the loss of this cable as an asset. The Directors propose to put £4,500 of the balance to the credit of profit and loss to the reserve fund, which will then amount to £14,300, and to carry forward £73. 12s. 2d. to next account.

The following special report is to be presented by the Directors at the extraordinary general meeting to follow the general meeting:—

The examination of the original Bilbao cable having resulted in showing that it could not be advantageously restored, the Company has now to adopt one of the alternatives pointed out in the opinion of Sir Horace Davey (to which reference has been made at previous meetings), and either

* Report of Mr. Carvill Lewis in *Pennsylvania Geological Survey*, 1884; also Dana's *Manual*.

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discontinue the payment of dividend on all the shares (including the preference shares) until sufficient money is accumulated to lay a new cable, or else take steps to write off a proper amount of the existing capital as unrepresented by assets. The Board have considered the position carefully, and find that the former alternative would, with the present revenue, involve the suspension of all dividends for ten years. But, on the other hand, to place the Company in a sound and dividend-paying position by writing off the lost capital, the following step may be taken, viz., reduce the nominal capital by writing off £5 per share on all the shares. If this were done, the arrears of dividend on the preference shares (£2. 10s. per share to the 31st December, 1886), could be at once paid, and the prospects of the shareholders would stand thus from the end of the present year:—

	Per annum.
Taking the average net revenue for the last three years.....	£12,750 0 0
And reserving for renewals and repairs	5,000 0 0
There would remain for appropriation as below	£7,750 0 0
Interest at 6 per cent. £62,000 debentures.....	£3,720 0 0
Dividend at 10 per cent. on £30,000 preference shares ...	3,000 0 0
Dividend at 2 per cent. on £51,724 ordinary shares.....	1,034 0 0
	£7,754 0 0

In the above calculation the reduced ordinary shares are treated as £5 shares with £4 paid on each, thus leaving the £1 liability on the ordinary shares as at present, and the Directors consider that this liability should remain, as the debenture holders might object to the scheme if it were proposed to extinguish it. There is no occasion for calling up the amount at present. It will be borne in mind, with reference to the proposal to reduce both classes of shares alike, that the preference shares confer no priority as regards capital, but in the event of a liquidation would suffer equally with the ordinary shares from the diminution of assets Special resolutions will be proposed to the meeting in the form which is appended to the notice convening it; they will require to be confirmed by a subsequent meeting, and to be afterwards approved by the High Court.

The French Atlantic Cable Company.

The directors of the French Atlantic Cable Company have issued a circular to the shareholders in view of the annual general meeting, which is to be held on October 6th. After referring to the very grave character of the business which is to be transacted at that meeting, and which, in the opinion of the Directors, involves the very existence of the Company *as a French company*, it is announced that, owing to the opposition which was manifested to their policy at the meeting in June last, and to the charges of maladministration which were then freely made, they had taken steps in accordance with the French law to have the position of the Company officially investigated. The report of the commissioners will be presented at the forthcoming meeting, and will be found to contain a complete vindication of the policy of the Directors. Owing to these unfounded charges, and owing more especially to the unfortunate war of tariffs in which they were most unwillingly compelled to engage, the management of the affairs of the Company had, during the last few months been a matter of considerable difficulty. It was, however, abundantly evident from the facts and figures which had now received the confirmation of the commissioners, that their financial position was perfectly sound. "As to the war of rates, we have always kept in view the desirability of bringing the matter to its earliest possible termination. It has been confidently asserted that a return to the tariff first adopted by the allied companies—namely, 2 francs per word—would now be capable of yielding an adequate return upon the capital invested. Notwithstanding our highly unfavourable experience of this rate, which was in force from December, 1884, to May, 1886, we are giving the whole question a fresh and impartial consideration. In the meantime, we are convinced that the experience which is being gained by the allied companies during the continuance of the present low rates will in future prove to be of the greatest value. The lowering of the tariff to 60 centimes per word has produced a total augmentation of traffic upon the cables of the allied companies amounting to 122 per cent., which produces a revenue equal to a charge of 1fr. 33c. per word upon the traffic under the old tariff. This permits our Company at the least to pay its way, while we are enabled at any time, after due examination, to adopt such a course as may seem most conducive to our own interests. In presence of these results it is permissible to affirm that in the event of a revival of trade the present tariff would certainly yield a revenue equal, if not superior, to that previously earned under the charge of 2fr. The facts tend also to show that the future of submarine cables depends as much upon the progress of the art of submarine telegraphy as upon the raising of tariffs." The document concludes with a repudiation of the assertion that the Directors had in any sense subordinated their own interests to those of the English companies, and appeals strongly to the shareholders for their support at the forthcoming meeting.

CRICKET.

The return cricket match between the Manchester and Liverpool centres of the Lancashire and Cheshire Telephone Exchange Company took place at Manchester on the 18th inst. After a pleasant game Manchester were again victorious. Score:—

MANCHESTER.—Beer, b. Martin, 0; Hodgkinson, b. Holmes, 11; Poole, b. Martin, 0; A. Pugh, c. Holmes, b. Uxley, 13; Hibbert, run out, 3; M'Pherson, b. Uxley, 2; Morris, sen., b. Uxley, 4; Morris, jun., b. Uxley, 0; W. Pugh, b. Uxley, 1; Clark, b. Uxley, 2; Partington, b. Uxley, 2; Bennett, not out, 0; extras, 12—total, 50.

LIVERPOOL.—Martin, run out, 5; Clough, b. Hibbert, 7; Currie, b. A. Pugh, 1; Jellard, b. A. Pugh, 0; Uxley, b. A. Pugh, 2; Holmes, c. and b. Hibbert, 0; France, b. A. Pugh, 3; Roberts, b. Hibbert, 1; Drummond, c. Partington, b. Hibbert, 7; Hodge, b. A. Pugh, 5; Day, b Hibbert, 0; Edgar, not out, 0; extras, 9—total, 40.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. SEPT. 22.		BUSINESS DONE WEEK ENDING SEPT. 22. Highest.	Lowest.
Anglo-American	32½,	33½	—	—
Do. Preferred	55,	56	55⅞	55
Do. Deferred	11½,	11⅝	11⅝	11⅜
Brazilian Submarine	10⅜,	11	1015-16	10⅜
Cuba	11,	11½	11⅜	—
Do. Preference	18,	19	—	—
Direct Spanish	1½,	2	—	—
Do. Preference	9,	10	9½	—
Direct United States Cable	8⅞,	9½	9 1-16	8⅞
Eastern Telegraph	11½,	11⅝	11⅝	11½
Do. 6 per Cent. Preference	14½,	15	14⅞	—
Do. 5 per Cent. Debentures, 1899	105,	108	—	—
Eastern Extension	11⅞,	12	12 7-16	11 13-16
German Union	9½,	9⅞	—	—
Globe Telegraph and Trust	6⅛,	6¼	6⅛	6 5-16
Do. Preference	13,	13½	13 5-16	13 1-16
Great Northern	13⅛,	13⅜	13⅜	13⅜
Indo-European	35,	36	—	—
Reuter's	6¾,	7¼	7	6 15-16
Submarine	195,	205	200	—
West India and Panama	⅝,	¾	11-16	—
Do. 1st Preference	8½,	9	8⅝	8½
Western Brazilian	6⅝,	6¾	6 11-16	6⅝
Western Union 7 per Cent. 1st Mortgage	118,	122	—	—
Do. 6 per Cent. Sterling Bonds	101,	103	—	—

TELEPHONES.

Consolid. Telephone and Maintenance..	13-16	15-16	—	—
Oriental	3-16	5-16	—	—
United Telephone	14⅜,	14⅝	14½	14 7-16

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)..	2,	2½	2 7-16	2⅜
Do. (fully paid)	4,	4½	4½	—
Swan	⅜,	1⅛	—	—
Maxim Weston	3-16	5-16	—	—

MISCELLANEOUS.

Telegraph Construction	39	40	39⅜	39½
India Rubber, Gutta Percha, and Telegraph Works	24	25	24½	—

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PHILIP MAGNUS, Director and Secretary.

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NOTES.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 24th ult. amounted to £3,601.

DETROIT.—At Detroit it is stated that there is one telephone in use to every fifty-one inhabitants, and each instrument is employed on the average 13·8 times daily.

A BIG CLOCK.—At Buffalo they are going to light by electricity a clock dial which is said to be the largest in the world. It is 25ft. in diameter, and is placed at a height of 360ft. above the ground.

STOCKPORT.—On the occasion of some recent local festivities at this town, the principal streets were illuminated by means of Jablochkoff lamps. The installation was carried out by Messrs. Durham and Co.

THE ELECTRIC LIGHT AT HELL GATE.—Owing to the numerous and emphatic complaints from pilots and captains as to the dazzling effect of the electric lights at Hell Gate, it is not unlikely that they will be discontinued.

GAS COMPANIES IN THE STATES.—The American papers contain week after week the names of gas companies in all parts of the country who have decided to undertake the supply of electric light upon their own account.

TELEGRAPHISTS' DINNER.—The Metropolitan District Telegraphists held their first annual dinner at the Victoria Mansions Restaurant on Friday last. There were about sixty present, and a very pleasant evening was spent.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended September 24th, were £2,817, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

TELEPHONE V. ELECTRIC LIGHT.—A test case is about to come before the American Courts in order to determine the question as to the right of electric light companies to erect cables in such proximity to telephone wires as to interfere with the telephone service.

TELEGRAPHIC FRAUDS.—Serious accusations are brought against certain of the local officials of the Western Union Cable lines as to systematic tampering with or delaying Stock Exchange messages, whereby it is believed that large sums have been fraudulently obtained.

ERRATUM.—In the second leader of last week there was an evident typographical error. The average cost per message under the old tariff was stated to have been "$12\frac{1}{7}$d., or nearly 1s. 1d." The figures should have read 12·97d. Similarly, in the line above, $8\frac{1}{16}$d. should read 8·16d.

AN ELECTRIC MACHINE GUN.—A resident of Sydney has brought under the notice of the Governor an electrical machine gun invented by him, which he claims is capable of firing 120 rounds every few seconds from any position and in any direction. The gun is stated to be easily portable, and it is attested by experienced officers to be an invention of considerable value.

PERSONAL.—Many of our readers will be interested to know that another member of the profession has recently ventured to become a Benedict. A few days since, at St. Peter's, Bournemouth, Mr. C. J. Wharton, of the well-known firm of Laing, Wharton, and Down, was married to Miss May Sybil Sandys, only daughter of Mr. James Sandys, of Bournemouth.

AMERICAN ELECTRICAL FINANCING.—A company has recently been launched in the States with a nominal capital of $4,000,000 for the purpose of introducing the Campbell Court Conduit. This we presume to be some kind of box for putting wires in, which at the same times makes a decent pavement kerb. It must be an uncommonly good box if it is going to pay interest on £800,000.

COLCHESTER.—That most unhappy episode in the history of the electric light in this country, which is connected with the lighting of the city of Colchester, may be considered to have been finally closed last week, when the entire plant came under the hammer of the autioneer. The total amount realised was £345. It may be added that this is about one quarter of the original cost of the *cables alone*.

BOOKS RECEIVED.—We have received a copy of "Short Lectures to Electrical Artisans," by Dr. J. A. Fleming, published by Messrs. E. and F. Spon. We have also received "Heroes of Science—Physicists," by Dr. Garnett, M.A., which is published by the Society for Promoting Christian Knowledge. The National Telephone Company have issued a new list of subscribers for their "Scottish North Central District."

DISTRIBUTION OF MOTIVE POWER AT BIRMINGHAM.—At Birmingham, a company is being promoted to distribute power by means of compressed air. It is estimated that under the given local conditions power can be supplied at a cost of about 20 per cent. less than steam power. It seems to be anticipated that the facilities to be furnished for running light machinery will have a considerable influence upon the extension of isolated electric lighting installations.

ELECTRICITY IN MINING.—According to the last reports of the Montana Company, the electrical appliances now at their works include one dynamo machine, supplying seven arc lights, and one 30 incandescent lamp dynamo machine, which are employed for lighting two of the stamp mills as well as some of the offices. Electric signal communication is also established between the millmen and the engine driver. Provision will shortly be made for about 60 additional lamps.

THE EASTERN EXTENSION TELEGRAPH COMPANY.—The Eastern Extension Telegraph Company notify that the accounts for the half-year ended 30th June last show, subject to audit, a balance of profit of £66,230 after payment of the interim dividend for the first quarter. The directors have declared a dividend for the quarter ended 30th June of 2s. 6d. per share, free of income-tax, payable on the 15th inst., and decided to carry forward the balance of £34,980 to next account. In consequence of the diminution of revenue the directors do not feel justified in paying any bonus for the past half year.

A SEVERE TEST.—We are informed that on board H.M.S. "Devastation" a "Kapp" dynamo was recently kept running for twenty-six continuous days and nights without cessation, and at the end of that time appeared to be in as good condition as at the beginning. This was not undertaken by way of experiment, but simply because the light was required during the whole of the time to facilitate repairs. The result simply shows that with a thoroughly well designed dynamo there is no limit to the length of time during which the machine may be continuously run, except the eventual and inevitable wear and tear of the commutator.

SUBMARINE PHOTOGRAPHY BY ELECTRIC LIGHT.—Experiments are about to be undertaken by MM. Bonfante and Maisonneuve on deep-sea photography by means of the incandescent light. Upon a smaller scale, and in comparatively shallow water, some success has already been attained in this direction by M. Pinard. In the case, for instance, of a sunken wreck which it might be proposed to raise, it is evident that

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if a camera could be arranged so as to be placed in the hands of the divers, results of considerable practical value might be attained. As for deep-sea photography, they would probably be more successful if taken with an arc light, and no doubt this could be done with a properly constructed lantern.

POLICE TELEGRAPHS.—A system is now being introduced in the States, and has for some time been in active operation at New Haven, Connecticut, whereby the police stations are at all times enabled to communicate with any of the men while on their beats. This is effected by means of a visual signal, similar to a railway semaphore, which is attached to certain of the street lamps, and is operated by electricity from the superintendent's office. A telephone placed in a locked box fixed to the same part enables the policeman on perceiving the signal to learn what is required. This is very pretty, no doubt, but we confess that it puzzles us to understand how they manage in the States to find the money to pay for all these little luxuries.

THE ESTIENNE TELEGRAPH.—The French Administration has for some time had under their consideration the question of introducing the Estienne system of telegraphy. They have at length determined to give the system a trial upon an extensive scale, and a special staff of operators has been formed to study the method of working. The special feature of the system is the substitution of vertical for horizontal lines in the Morse alphabet, and, so far, we fail to see where it is essentially different from the system long ago proposed in this country by Mr. Richard Herring.

NEW CABLE.—A telegraph cable is to be laid between Cape York and Thursday Island, Queensland. The tender of the Eastern Extension Company for the supply, transportation, and laying of the cable for £10,000 has been accepted. A two-cored brass-ribboned cable of the latest form has been manufactured by the Telegraph Construction and Maintenance Company, and is now on its way to Singapore, where it will be put on board one of the Eastern Extension Company's steamers and thence conveyed to its destination. It is expected the cable will be completed during November.

FORGING A TELEGRAM.—At the Hammersmith Police Court on Wednesday, a servant out of place, named Eliza Davis, was charged before Mr. Partridge with forging and uttering a telegram, purporting to be sent by one H. Newman, of 27, Great Portland-street, to Mrs. Newman, of 173, Portobello-road, on Friday last. It ran as follows :—"Your husband has met with an accident. He is dying. Come at once. Father." Evidence having been given by Mrs. Newman and the Post Office authorities proving that the prisoner had sent the telegram, Mr. Partridge remanded her for a week to consider how he should deal with the case.

TEMPORARY ELECTRIC LIGHTING.—Messrs. G. Binswanger and Company are introducing the Pollak regenerative cell for the purpose more especially of temporary installations of incandescent lighting. This cell, which is one of that very limited class which has a valid claim to be based upon a new principle, has also several features which render it suitable for the purpose above referred to. We have already described and illustrated the cell, but we may add that its "self-regenerative" powers depend upon the action of the atmosphere. Oxygen is continuously absorbed by the upper part of the carbon (which is of a specially porous texture), and is thus brought into intimate relation with the electrolytic hydrogen.

DIELECTRIC FLUIDS.—Prof. G. Quincke, continuing his studies of the properties of dielectric fluids, publishes in the last number of the *Annalen der Physik und Chemie* some results of experiments with very high electromotive forces. By means of a Holtz machine and a long-range electrometer the observations have been carried up to 30,000 volts. Prof. Quincke finds that an apparent exception to the law of Ohm occurs under these conditions, inasmuch as the strength of a steady current through the fluid increases more rapidly than the electromotive force which produces it. It was also observed that with high electromotive forces the dielectric constant (the inverse of specific inductive capacity) is less than with lower forces; in other words, there exists an apparent tendency to saturation in inductive capacity.

ELECTRICITY IN SOAP AND BLEACHING WORKS.—M. Rotondi has discovered that by the employment of suitable vessels, it is possible to effect the saponification of oils by the electrolysis of an emulsion of the oil in a concentrated solution of sodic chloride. This, at least, is the nature of the process so far as we can gather from a not very lucid description in one of the French technical journals. During the process it is said that caustic soda, free chlorine, and glycerine are formed, and it is suggested that at bleaching works it would be found economical to prepare chlorine by this process in order to obtain the soap and the glycerine as by-products. It is also suggested that as the process requires practically no supervision, it would be practicable to employ in this way at night, steam-power already in use during the day-time for other purposes.

WEST AFRICAN CABLES.—The Silvertown Company has received telegraphic advices from Mr. Matthew Hamilton Gray, the engineer in charge of the expedition, announcing the completion of the West African Telegraph Company's system of cables. These cables are laid in 10 sections of a total length of about 3,600 nautical miles, and, in conjunction with the cables just completed for the African Direct Telegraph Company by the Telegraph Construction and Maintenance Company, give telegraph communication with Europe to the principal ports of West Africa as far south as St. Paul de Loanda, and a duplicate communication to Bathurst and Sierra Leone. The cable steamer "Silvertown" is expected to arrive in London about the beginning of November, and the cable steamer "Dacia," which was also occupied in this work, is expected to arrive home on Saturday next.

FLUORINE BY ELECTROLYSIS.—M. Moisson has contributed to the Academie des Sciences a further note upon his recent discovery of a method of obtaining fluorine by electrolysis. His later experiments tend to add further confirmation of the fact that the gas which is obtained by this process is the element itself, and not a hydrogen fluoride, as was at first thought possible. By mixing fluoric acid with potassic fluoride, which greatly increases its conductibility, and also by surrounding it with a freezing mixture capable of reducing the temperature to $-50°$ C., M. Moisson is now able to obtain the separation of the gas with an electromotive force of only 10 Bunsen cells. The liquid is placed in a platinum capsule, which serves as one of the electrodes, and the other pole is formed by a platinum wire, which dips into the liquid. Unless the temperature be kept very low the platinum is attacked with rapidity by the liberated gas.

ELECTRIC BUOYS.—Some experiments have recently been carried out at Asnières with a buoy which carries an incandescent lamp, supplied by accumulators. Although the experiments are described as being highly successful, we certainly do not consider this at all a promising field for the application of accumulators. The Pintsch system of storing gas under pressure in the buoy, and by means of which it may be left without attention for a month or more, is decidedly superior

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to a battery arrangement for this particular purpose. Upon a less ambitious scale, however, the idea may possibly have some value. It has been suggested that a small battery might be attached to a life buoy with an arrangement by which the lamp is brought into the circuit upon contact with the water. Even here, however, the Silas life buoy, which on falling into the water shows a light by means of phosphide of calcium, is probably very much cheaper.

ARC LAMP EFFICIENCY.—According to the Hartford *Courant*, from certain tests which have recently been made in that city upon an arc lamp circuit, which has a length of over seven miles, with forty-six arcs, the power expended in the external circuit, including that lost in the leads, was equal to 0·58 horse-power per lamp of 2,000 candle-power. It does not, however, appear that any photometric observations were undertaken, and we all know that the ratio between the nominal and actual power of an arc lamp must be taken in the inverse sense to that of a steam engine. The horse power developed was apparently calculated from indicator diagrams, which gave 31·5 horse-power. From this 4·88 horse-power was deducted for friction of engine and dynamo, leaving 26·62 horse-power available for the 46 lamps. The system employed at Hartford is that of the Waterhouse Company, but we fear that more substantial evidence must be adduced before an efficiency of 4,000 candles per horse-power will be accepted on this side of the Atlantic.

THE SS. "ORIZABA."—The latest addition to the magnificent fleet of the Pacific Steamship Navigation Company is named the "Orizaba." She has this week left the Albert Dock upon her trial trip. The electric lighting upon this vessel is provided for by means of two 300 light 16 candle-powder slow-speed Kapp dynamos, which are driven direct from two compound engines, running at 250 revolutions. The four machines are placed in one line, the two engines being side by side in the centre, and by means of a coupling between the engine shafts either or both of the engines may drive either or both dynamos. This arrangement has been adopted at the suggestion of Mr. Brice Douglas, M.I.C.E., engineer-in-chief to the company. The machines are built for an output of 240 amperes at 55 volts, and in order to provide for the very high temperature which exists in the engine rooms of vessels passing through the Red Sea fans have been supplied to cool the dynamos, while at the same time the machines are specially designed to have a very low current density in all the coils, together with a large cooling surface.

"ENCORE CREIL."—Under this title *L'Electricien* reproduces at length a highly amusing article from a French provincial journal, in which Prof. Elihu Thomson's process of electric welding is ascribed to "certain Russian savants," to whom M. Marcel Deprez is said to have lent his laboratory and his advice. This process has, however, been greatly developed since Prof. Thomson has had anything to do with it, for we are assured that a weld can now be effected under water, so that, according to our authority, an ironclad may in future have her plates re riveted beneath the water-line without ever being docked. This is one of the finest examples of the scientific use of the imagination which we have come across for a very long while. Since writing the above we notice that our French contemporary, *Cosmos*, repeats the statement as to experiments upon electric welding carried out by Russian savants at Creil, but without committing itself to the submarine details. Perhaps, therefore, it will be better to wait to hear further who these Russians are, and what they have really done, before joining M. Hospitalier in his chaff at their expense.

SHUNTING ELECTRO-MAGNETS ON TELEPHONE LINES.—In connection with the remarks which we made last week upon this subject, when speaking of the "anti-induction" telephone cables, it is somewhat singular to note that at the Telephone Convention, which has just been held at St. Louis, a self-acting device of a similar character was exhibited under the name of a "reducer." This little apparatus is the invention of Mr. C. D. Wright, of Petersburg, Ill. Under normal conditions the bell or annunciator coils are short-circuited by the armature of a small relay of low resistance; when the call signal is given, this relay opens the short circuit, and throws a portion of the current through the coils of the bell or annunciator. Thus, while the telephone is in use the bell coils are always short-circuited. We have no doubt that this device is a good one, and are not surprised that it was well spoken of at St. Louis by the telephone men who had tried it; at the same time, it does not seem that any of them supposed the effects to be due to anything else than the simple reduction of the metallic resistance of the circuit.

PROPOSED CABLE TO TORY ISLAND.—Tory Island is a lighthouse station lying off the extreme north-west of Ireland. It is the turning point, so to speak, for all vessels coming from the south or south-west, and using the north of Ireland route for Liverpool, Londonderry, Belfast, Glasgow, and other ports. Sir E. W. Watkin, writing to the *Standard*, points out the very great advantage which would accrue to shipowners from the laying of a cable connecting this point with the main land. According to Sir E. Watkin, five hours would be saved in signalling steam ships, and the advantage to sailing ships would be even greater, for it appears that vessels coming eastward are frequently delayed for days, and even weeks, by adverse winds off this part of the coast, without being able to communicate with their owners, who, if informed by telegraph, could at once send tugs to their relief. Sir E. Watkin estimates the cost of the cable at £2,500 if landed at Traymore Bay, or £6,000 if landed at Malin Head. It is, however, to be remembered that the cost of maintaining the cable is in cases of this kind a consideration of greater importance than the first outlay.

A NEW APPLICATION OF THE PHOTOPHONE.—M. Leon Esquille has found it possible to employ photography and electricity together, for the purpose of recording and reproducing speech in a more direct manner than has hitherto been done. M. Esquille's method consists in speaking in the first instance to a photophone transmitter. Our readers will remember that this is merely a diaphragm with a highly polished surface from which a ray of light is reflected. The record of this speech is then obtained by simply photographing the ray of light upon a travelling band of sensitized paper. After having been developed, the articulation may be reproduced by projecting the image of the trace by means of an electric arc or oxyhydrogen light upon a selenium receiver, preferably one of the form due to M. Mercadier. The speech is then heard through the telephone in the usual manner. It seems highly probable that, although this method is certainly more troublesome, it will give results superior to those of instruments which, like Edison's phonograph and Prof. Bell's more recent "graphophone," depend initially upon a mechanically formed trace of the sound vibrations.

TELEPHONE LITIGATION.—We hear that the telephone war is about to break out again in an old quarter. Writs have been issued by the New Telephone Company against the Western Counties and South Wales Telephone Company and against Mr. Lewis, their manager, and their district superin-

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tendent at Bournemouth, Mr. O'Donnell, for alleged slander of title. The United Telephone Company, who for some time maintained that their patents were infringed by the New Telephone Company, were understood to be about to bring an action for infringment against that company on this ground; but when challenged in Mr. Justice Chitty's court to substantiate their threats, they declined to do so, virtually admitting that there was no infringment by the New Telephone Company. The New Telephone Company, however, allege that the licensees of the United Company have, nevertheless, continued to circulate false statements to that effect, to the damage of the New Telephone Company's business, and the latter have opened fire by serving writs upon the Western Counties Company. As the statements of infringment, rightfully or wrongfully, have been made openly and wholesale, heavy damages will be claimed.

THE LISBON TELEPHONE SERVICE.—On the authority of the *Diario Popular*, of Lisbon, we recently stated that the telephone service in that city was the subject of considerable complaint. Our strict sense of justice now leads us to reproduce the following recantation, which appeared in the issue of that paper on the 17th ult. :—"In justice to the Telephone Company of this city, who, in spite of the many great difficulties they have met with on all sides, have introduced such an important improvement amongst us, we would now make a few remarks regarding a paragraph we lately published concerning the same, in which we complained of the switch room service. Since writing the paragraph in question we have noticed a great improvement in the service, and, having ascertained the reason, find that at the time we complained some of the chief operators at the exchange had recently left, and had to be replaced by others to whom this service was entirely new, and who at the time had not yet learnt the art of operating. Also as regards our statement that many of the subscribers did not intend to renew their subscriptions, we are very glad to learn that we were entirely misinformed, and that it had no foundation whatever in fact."

THE PROPOSED ELECTRIC LIGHTING AT BOURNEMOUTH.—The project for a public supply of incandescent light at Bournemouth is being followed up with some vigour by the townspeople. Since our last "Note" upon the subject a meeting has been held at the Town Hall to consider the question of taking steps to form an Electric Lighting Company. It was estimated that a capital of £3,000 would be required, and several of those present expressed their intention of applying for shares, so that there is very little doubt that the installation will be proceeded with. "A gentlemen in the body of the hall" raised some objection, on the score of the supposed dangers to life resulting from the electric light. Considering that only incandescent lights upon a low tension system are in question, Mr. Shepherd does not appear (according to the newspaper report) to have expressed himself as strongly as he might have done as to the absence of all risk of the kind referred to. He was, however, able to adopt the practical expedient of an appeal to another gentleman present, who stated that at Mr. Shepherd's request, although feeling rather nervous about it, he had actually touched a wire supplying an incandescent light—and had survived the experiment; in fact, as he went on to add—and evidently much to his own surprise—he did not feel the slightest sensation at the critical moment. The public still require a good deal of enlightenment on points of this character.

ELECTRIC PROGRESS IN CANADA.—At Toronto an electric railway has just commenced running, and has so far proved a success. The motor, which was designed and constructed by Mr. J. Wright, of the Toronto Electric Light Company, presents several novel features. We take the following account from the *Electrical World*, of New York:—The armature is built up of removable coils wound in a mould and made interchangeable. A defective coil can thus be replaced in a very short time. An electric light is placed in a powerful reflector in front of the car, and remains constantly lighted, as the current is never interrupted. The power is conveyed to the driving wheels by friction gearing, which admits of the motor being always in operation except at the moment of reversing its direction of rotation. When the motor is released from the gearing for stopping the car, it is prevented from accelerating its speed by the introduction of resistances in the circuit. Part of the resistance is in the form of coils of fine wire encircling an extension of the iron of the brake shoes, which are thus converted into powerful magnets, and bring the car to a standstill without any manual power being applied to the brake at all. There is also a double gong on the upper part of the front of the locomotive actuated by a small quantity of the current in a derived circuit to the main line. While on the grade the current rose from 15 amperes to 25, which was the highest recorded. The E.M.F. of the generator at 750 revolutions is about 2,000 volts.

"LA SUITE DES EXPÉRIENCES DE CREIL."—Under this title the *Revue Industrielle* has the following remarks:—"One of the most surprising results of the late experiments of M. Marcal Deprez for the electric transmission of force between Paris and Creil has been to reduce to silence the journal, *La Lumière Electrique*, which has hitherto been devoted to the glorification of the enterprising academician. This sudden change of attitude has caused no little surprise among those who have not been initiated into the mysteries of financial syndicates. It is said that harmony no longer reigns among the promoters of the enterprise, and rumours are even current as to legal processes involving claims for indemnity, or for damages, amounting to millions of francs. We do not pretend fully to understand the relations of the house of Rothschild with these matters, but it is well known that kissing goes by favour, and, in any case, we shall be very curious to know what foundation there may really be for these rumours of serious disagreements. It is perhaps permissible to believe, in financial circles, that M. Marcel Deprez has made some great discovery; delusions of this character are common even among the first financiers of the world. But, from an industrial point of view, we have still to learn that any practical value attaches to the Creil experiments." The article concludes with some remarks of great severity as to the personal distinctions or advantages which "certain persons" are said to have derived from the business.

CIVIL SERVICE INQUIRY.—*Apropos* of the controversy now going on in the *Daily Telegraph* on this subject, one correspondent from Birmingham writes to that paper as follows:—"I am more than surprised to find that no member of the postal telegraph service has thought fit to join in the controversy now going on in your paper concerning the Civil Service inquiry. Although it is clear that there is to be a big levelling down, it is to be hoped that there will also be a big levelling up with respect to those who were handed over to the tender mercies of the Post Office by the telegraph companies; for, though it may not be publicly known, great dissatisfaction exists among them in consequence of their having been deprived of their legal rights. As one of the number so transferred, it will be sufficient to state my own position. In taking over the property of the telegraph companies the Act of Parliament provided that all clerks retained by the Government were to

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be, to all intents aud purposes, officers of the Civil Service, and as such were to be entitled to all the privileges of that service, but when the Order in Council gave effect to certain recommendations of the Playfair Commission the telegraph clerks were excluded, and have been excluded to this day, even from the lower division of the scheme, and as a consequence I, like many others, stand in receipt of £130 per annum, after considerably more than twenty years' service. And my duties are, what? To be able to ascertain and determine the nature and locality of interruptions on telegraph lines; to be well versed in the laws of electromotive force; to be competent to remedy faults in electrical appliances—in short, to be an electrician, and to occasionally assist in the control of large bodies of men."

An "All-Round" Battery.—The October number of the Maderia *Monthly Correspondent* contains the following:—"A want has lately been felt of a good 'all-round' battery; one, not only of the *constant* type, but one which will work equally well—(1) On cable circuits; (2) On land lines; (3) On house electric bells and annunciator; (4) As an exciter for recorder vibrators; (5) As a testing battery. With this end in view, we have lately thoroughly tested and have now in constant use on a cable circuit a battery of modified gravity cells of a form suggested by one of M. Hospitalier's books. Circumstances, however, have compelled us to adopt a slight modification, as to form and shape, from the drawing given in the book of the eminent French electrician. Our cell is as follows:—The + pole is a piece of *lead* piping filled with sulphate of copper and slit at the bottom, the slit pieces being opened out so that the lead piping stands up easily in centre of cell. Unfortunately we have to utilise the old Minotto jars, which are of the roughest make, and some of which are not even straight, and with bottoms all on one side, owing to bad manipulation of glass. The edge of glass jar supports the out-reaching lappets of the – pole, a massive ring of *zinc*, through which the lead piping freely passes. We are having all our old refuse zinc recast into zincs of the above form, and all useless old Minotto coppers are replaced by this cheap substitute, lead-piping, which answers very well. Charged with a weak solution of sulphate of zinc, the above battery is about 3ω per cell, but after working for two or three weeks, falls to 2ω per cell, at which resistance it remains. If one set up the battery by filling up with water, and short-circuiting for a short time, the battery is at first about 17ω, and then, as the sulphate of zinc is formed, gradually falls to 2ω per cell. When the cell requires more sulphate of copper a little is dropped into the lead piping. We had a battery of these cells on closed circuit for a week, and every morning rough tests for R and E.M.F. were applied; its behaviour was perfect."

New York Wires.—In order to avoid having to place their lines in the conduit, now being laid down in New York, the Western Union Telegraph Company have concluded an arrangement with the Elevated Railway Company in that city for placing their lines underneath the railway structures. This is now being carried out; we can only wonder that so obvious an arrangement was not long ago adopted. As to the conduit itself, the work proceeds slowly; more than once unexpected difficulties have arisen in the way of large gas and water pipes, which are often found to occupy very different positions from those shown upon the plans. The conduit sections also are not being supplied as rapidly as had been promised by the makers; and, further, there are several lawsuits pending on different matters connected with the action of the Subway Commissioners; among others the latter are themselves bringing an action against the Western Union Company to compel them to place their wires in the subway. As the conduit is not yet complete, this seems rather premature. The following details of the specifications for the material of the conduit have not as yet appeared in this country:—The specifications call for a material which shall bear a crushing strain of 4,000 pounds per square inch, a tensile strain of 300 pounds per square inch, that will not crack at 10° F. or soften below 160°, and that will not lose shape under 200° F. It must also be impervious, and resist the action of illuminating gas, salt water, and organic acids. The sand used to be silicious, clean and sharp, and heated before mixing with the asphalte to the temperature of the latter. The natural bitumen, if used, to be freed from water, and contain in the semi-refined mastic not less than 60 per cent. of pure bitumen. No petroleum refuse or still bottoms to be used for softening it, but preferably paraffin or paraffin oil. The conduits are to be rectangular in section, containing 2½in. ducts, varying in number. The conduit is to rest on a foundation of Portland cement concrete 6in. thick. The method of joining the sections to secure tightness is by the use of paper tubes covered with coal-tar pitch. Manholes are to be built at street-crossings. The specification would seem to be deficient in requiring no test as to expansion and contraction from changes of temperature.

The Phœnix Fire Office Rules.—The eighth edition of these rules has just made its appearance, and contains the regulations which have been adopted for the use of secondary generators. They are as follows:—"Where secondary generators are employed and the alternating primary current is of high electromotive force, it is preferable that neither the secondary generators nor the portion of the primary circuit in connection with them be placed inside any building, but in a fireproof structure apart. When, however, this cannot conveniently be done, the following precautions must be observed: The primary conductors must be heavily insulated with india rubber of the highest quality, or other approved equally good material or materials, and must have a very strong external covering, and the insulation resistance must be very high, and to the satisfaction of the inspector from the fire office. The conductors must be kept at a minimum distance of twelve inches from each other, and be enclosed in separate casing. The casing should be of a non-conducting material and fireproof, and the arrangement must be such that no leakage of electricity can take place to earth from either of the conductors, or any short circuit from one to the other. The primary conductors must be furnished with a double-pole switch, and also double-pole 'cut-outs' which act at 25 per cent. above the normal and placed as near the entrance of the primary conductors into the building as possible. The switch-board must be of slate or other approved non-combustible material, and placed in a secure position The secondary generators must be encased in iron, or be in a fireproof compartment, and placed as near the entrance of the primary conductors into the building as can conveniently be done. They should be in a dry situation and thoroughly insulated. All secondary conductors must be protected by double-pole 'cut-outs' to go at 50 per cent. above the normal, to be approved by the inspector from the Fire Office. Where from the nature of circumstances it is found impossible to follow out any part or parts of these safe-guards, then the inspector from the Fire Office will decide as to what shall be done in each particular case as it arises. The casings for the primary conductors must be fireproof from their entrance into a building up to the 'cut-outs.' Should, however, it be desired to use non-fireproof casing from the 'cut-outs' to the switch and secondary generators, special permission must first be obtained."

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CONTEMPORARY PROGRESS.*

ON AMPERE'S LAW.

By P. DUHEM, *Journal de Physique*, 2nd Series, Vol. V., 1886.

Gauss was the first to enunciate the following proposition:—

"There are an infinite number of laws for the action of one current element upon another, such that the action of a closed current upon a current element shall be the same as that obtained from Ampère's law. But of these, Ampère's law is the only one for which the action of one current element upon another reduces to a single force in the straight line joining the two elements."

The following seems to be a particularly simple proof:—

Gauss's theorem will follow immediately if we can show that the action of one current element upon another is completely determined, when the action of a closed steady current upon a current element is known, by the condition that the mutual action of two elements shall be in the direction of the straight line joining them.

Let ds, ds' be the two current elements; i, i' the currents in them. Let us suppose that there are two distinct expressions representing the action of ds on ds', both subject to the assumed conditions. The components of the force exerted by ds on ds' will be for the two expressions respectively:—

$$\begin{matrix} ii'\,X\,ds\,ds' \\ ii'\,Y\,ds\,ds' \\ ii'\,Z\,ds\,ds' \end{matrix} \quad \text{and} \quad \begin{matrix} ii'\,X_1\,ds\,ds' \\ ii'\,Y_1\,ds\,ds' \\ ii'\,Z_1\,ds\,ds' \end{matrix}$$

Let ds form part of a closed circuit; then, since the action of the circuit is the same for either law,

$$\int X\,ds = \int X_1\,ds$$
$$\int Y\,ds = \int Y_1\,ds$$
$$\int Z\,ds = \int Z_1\,ds,$$

the integrals being taken round the closed circuit.

Hence
$$\left.\begin{matrix} (X-X_1)\,ds = d\,F \\ (Y-Y_1)\,ds = d\,G \\ (Z-Z_1)\,ds = d\,H \end{matrix}\right\} \quad . \quad . \quad . \quad (1)$$

where F, G, H are functions of the co-ordinates, x, y, z, of the element ds.

If in each case the resultant action is along the straight line joining ds and ds', we shall have, where x', y', z', are the co-ordinates of ds',

$$\begin{matrix} (y'-y)\,Z - (z'-z)\,Y = 0 \\ (z'-z)\,X - (x'-x)\,Z = 0 \\ (x'-x)\,Y - (y'-y)\,X = 0 \end{matrix}$$

and
$$\begin{matrix} (y'-y)\,Z_1 - (z'-z)\,Y_1 = 0 \\ (z'-z)\,X_1 - (x'-x)\,Z_1 = 0 \\ (x'-x)\,Y_1 - (y'-y)\,X_1 = 0 \end{matrix}$$

Hence from equations (1)—

$$\left.\begin{matrix} (y'-y)\,d\,H - (z'-z)\,d\,G = 0 \\ (z'-z)\,d\,F - (x'-x)\,d\,H = 0 \\ (x'-x)\,d\,G - (y'-y)\,d\,F = 0 \end{matrix}\right\} \quad . \quad . \quad . \quad (2)$$

If we write
$$\begin{matrix} (y'-y)\,H - (z'-z)\,G = F_1 \\ (z'-z)\,F - (x'-x)\,H = G_1 \\ (x'-x)\,G - (y'-y)\,F = H_1 \end{matrix}$$

Equations (2) take the form—

$$\left.\begin{matrix} H\,dy - G\,dz = -d\,F_1 \\ F\,dz - H\,dx = -d\,G_1 \\ G\,dx - F\,dy = -d\,H_1 \end{matrix}\right\} \quad . \quad . \quad . \quad (3)$$

From the first of these we see that F_1, and therefore also its partial derivatives H and G, are independent of x. Applying the same reasoning to the two others we find that

F is a function of x only,
G is a function of y only,
H is a function of z only.

Again, since the left hand members of equations (3) are complete differentials,

$$\frac{\partial H}{\partial z} + \frac{\partial G}{\partial y} = 0$$
$$\frac{\partial F}{\partial x} + \frac{\partial H}{\partial z} = 0$$
$$\frac{\partial G}{\partial y} + \frac{\partial F}{\partial x} = 0$$

Whence
$$\frac{\partial F}{\partial x} = \frac{\partial G}{\partial y} = \frac{\partial H}{\partial z} = 0.$$

Thus F, G, H are constants; and therefore, from equations (1),

$$X = X_1$$
$$Y = Y_1$$
$$Z = Z_1,$$

which proves our proposition.

ON THE ELECTRICAL CONDUCTIVITY OF DOUBLE SALTS.

By E. KLEIN, *Wied. Ann.*, Vol. XXVII., 1886.

The principal object of the author in these experiments, made both with double salts and with mixtures of salts, was to obtain data which would give some insight into the condition in which such salts exist when in solution.

It has generally been maintained that double salts always become dissociated when in solution, but these conclusions do not rest upon direct experimental evidence, but only upon probable suppositions. The author refers to a large number of researches by different inquirers who all agree on the point that dissociation occurs, but the question whether this dissociation is complete or only partial had still to be decided.

The resistance measurements were made by the aid of a Wheatstone bridge of Kohlrausch's form, with sliding contact and alternate currents. The dynamometer was replaced by a telephone, and an induction coil was used to generate the currents.

The bridge wire, the resistance coils, and the thermometers used in the experiments were carefully calibrated, and the errors from all sources were not more than from 3 to 5 per cent.

The salts used were the sulphates of magnesium, ammonium, potassium, sodium, iron, manganese, and nickel, and the chlorides of potassium and sodium, together with their double salts and mixtures. The solutions were prepared, not according to the specific weights, but according to the number of molecules contained in a litre, by which is meant (according to Kohlrausch in the case of simple salts) the number of grammes of the salt in a litre of the solution at 18°, divided by the electro-chemical molecular weight of the salt.

It was in this way that F. Kohlrausch was able to obtain a general insight into the complicated phenomena of electrical conductivity.

This electro-chemical molecular weight is equal to the ordinary chemical molecular weight, divided by the number of "*bonds*" set free during the electrolytic decomposition, as, for example, $K - Cl$; $NH_4 - NO_3$; $\frac{1}{2}(Ba = Cl_2)$; $\frac{1}{2}(H_2 = SO_4)$; $\frac{1}{3}(H_3 \equiv PO_4)$ (*Wied. Ann.*, Vol. VI., p. 146, 1879).

In the case of double salts and mixtures the number of molecules m must be somewhat differently defined, since the number of molecules must be referred to two litres instead of one. Then if two fluids with molecule number m be mixed, the resulting mixture will also have the molecule number m, even although every pair of molecules form one double molecule.

The molecule number will therefore be defined by the expression,

$$m = \frac{ps}{A} . 1000,$$

where p is the weight of the electrolyte per unit weight of the solution, s the specific weight of the solution at 18°, and A the electro-chemical molecular weight.

Some determinations were first made of the resistances of the simple salts, and the results agreed well with those

* Compiled and translated by G. W. de Tunzelmann. Continued from No. 17, Vol. XXVII.

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obtained by Kohlrausch, who had previously investigated the electrical conductivity of most of the simple salts already mentioned. The measurements of the conductivity k were made at temperatures of 18° and 26°. The mean temperature coefficient at 22° was expressed in the form,

$$\frac{\Delta k_{22}}{k_{18}} = \frac{k_{22} - k_{18}}{k_{18}},$$

k_{22} and k_{18} being the values of k at the temperatures 22° and 18° respectively.

Fig. 1 shows the curves obtained for the conductivity and the temperature coefficient, defined as above, for the sulphates of iron and of nickel, for different values of m, the values of m being taken as abscissæ, and the ordinates being the values of R and $\Delta k_{22}/k_{18}$ respectively.

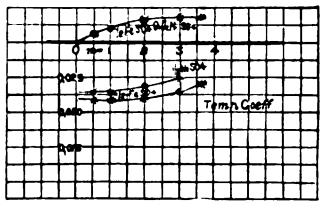

FIG. 1.

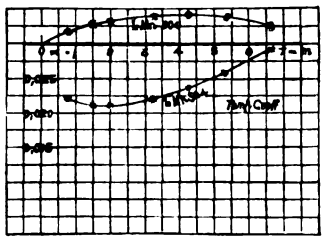

FIG. 2.

Fig. 2 gives the same curves for sulphate of manganese.

It will be noticed that the curve giving the temperature coefficient is in each case a sort of distorted reflection of the conductivity curves.

Conductivity of the Mixtures.

The mixtures may be divided into two classes.

1. Those which cannot undergo double decomposition, viz., when two salts contain either the same base or the same acid, excluding such mixtures as form double salts; they must therefore be of the form $AB + AB_1$ or $AB + A_1B$.

2. Those which can undergo double decomposition, viz., when the two salts contain different acids and different bases, being therefore of the form $AB + A_1B_1$.

There are two ways of comparing the electrical conductivities of the mixtures with the conductivities of the simple salts.

One way would be to measure the conductivities of equal volumes of solutions of the two simple salts, and then to measure the conductivity of the same volume of the mixture, and see whether in the latter case the conductivity is the sum of the two separate conductivities. Or, the two liquids may be mixed, and it may be determined whether the conductivity of the mixture be equal to the arithmetic mean of the conductivities of the components.

The two methods are not identical, and it is easy to see that the latter is the one which must be used.

The electrical conductivity of liquids is no simple phenomenon, but depends on the most widely differing factors; on the number of molecules, on their separate velocities, on the viscosity and frictional resistance between the molecules of the salt and of the medium in which it is dissolved, and finally on the chemical constitution of the solution.

The conductivity k may be defined as that strength of current due to a unit E.M.F. in a conductor of unit length and section. The current strength is, however, that quantity of electricity which crosses a section of the conductor in unit time. Now, in electrolytes the electricity is carried by the molecules of the salt, and therefore the current is proportional to the number of molecules crossing a section in unit time, and this number is itself proportional to the number m of molecules in the liquid, and to the velocity with which they cross the section. But this velocity is equal to the sum of the separate velocities of the constituent portions of the molecule, which leads to the known relation,

$$k = (u + v)m.$$

The velocity $u + v$ depends on the medium of solution, the degree of concentration, &c.

In the case of very dilute solutions $u + v = \lambda$, where λ is the molecular conductivity; and therefore the influence of the separate molecules of the salt on their motion can be neglected, and there remains only to take account of the frictional resistance of the medium. If to the very dilute solution of a salt there be added another, which if dissolved alone in the same would have a conductivity $k_1 = (u_1 + v_1)m_1$, the two salts will not interfere, provided they do not act chemically on each other. Since the solvent is in large quantity compared to that of the salts, therefore the molecules of either salt are able to pass a section as well as though the other were not present. It follows, then, that the conductivity of the mixture must be $k^1 = \phi(m)(m + m_1)$ where $\phi(m)$ is the velocity of the different molecules, having the constant value $u + v$ for one salt, and $u_1 + v_1$ for the other, so that $k^1 = k + k_1$, a law which Arvhenius (*Wiedemann's Beiblätter*, Vol. IX., p. 437) expressed as follows: "If two (or more) salts be dissolved in the same non conducting solvent, the conductivity of the solution is equal to the sum of the conductivities which the solution would have if in the first case one of the salts only were in solution, and in the second case the other only."

This law no longer holds for less dilute solutions, because there are then so many more molecules in a given volume of the solution.

If, however, the two salts be dissolved in such a way that the number of molecules per unit of volume is the same in each case as in the case of two solutions containing the same number of molecules, then the conductivity will be the mean of the two separate conductivities. In the experiments, therefore, with mixtures and double salts the solutions were so prepared that the number of molecules per unit of volume was the same as in the case of the simple salts.

The law of the arithmetic mean does not hold for very highly concentrated solutions, for even if the number of molecules be the same the specific weight and the fluidity of the mixture will be different.

Besides, with highly concentrated solutions the encounters of separate *ions* take place more easily and more frequently, and can no longer be neglected. Besides, it is probable that in concentrated solutions (as Hittorf has shown to be the case with iodide of cadmium) the single molecules collect into larger groups, and act electrolytically like ordinary molecules, the result being a smaller number of molecules, and a diminution in their velocity due to their increased size.

Possibly this may hold good for all simple salts, in which case the nature of the curves of conductivity would be perfectly accounted for.

The accompanying table A gives the results obtained with some of the mixtures experimented upon. The values of k in the second column are at the temperatures 18° and 26° respectively. The third column gives the arithmetic mean values of k for the two salts separately. D stands for the difference between the observed value of k for the mixture and its mean value for the two salts, expressed as a percentage of the mean. The sixth column gives the arithmetic mean value of $\Delta k_{22}/k_{18}$ for the two salts separately.

The figures for the first two mixtures show that for moderately concentrated mixed solutions of two salts having either the base or the acid in common, the conductivity is very nearly equal to the arithmetic mean of the conductivities of the two salts separately, but the mean is always slightly in excess.

In the case of the last two mixtures, which are of a kind capable of double decomposition, the conductivities are nearly the same, leading to the conclusion that two solutions of the form $AB + A_1B_1$ and $AB_1 + A_1B$ respectively, are identical,

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a result obtained in an entirely different manner by Ostwald (*Wied. Ann.*, Vol. VIII., p. 154, 1878), and also by Rüdolff (*Pogg. Ann.*, Vol. CXLVIII., p. 574, 1873). Since the conductivity of the mixture is more nearly equal to the mean conductivity of its constituents in the case of the mixture $NaCl + \frac{1}{2}K_2SO_4$,

TABLE A.

M.	10^6k at 18° and 26° C.	Mean.	D	$\frac{\Delta k_{22}}{k_{18}}$	Mean.
		$\frac{1}{2}K_2SO_4 + KCl$.			
0·5	421·5	424·7	−0·8		
	493·1	496·6	−0·7	0·0212	0·0215
1	788·5	795·3	−0·9		
	915·9	923·3	−0·8	0·0202	0·0202
		$\frac{1}{2}Na_2SO_4 + \frac{1}{2}K_2SO_4$.			
0·5	322·0	324·2	−0·7		
	380·7	383·4	−0·7	0·0228	0·0230
1	570·1	576·6	−1·0		
	673·4	678·1	−0·7	0·0227	0·0225
		$NaCl + \frac{1}{2}K_2SO_4$.			
0·5	369·2	374·6	−1·4		
	435·2	442·0	−1·5	0·0224	0·0224
1	678·1	686·4	−1·2		
	794·9	804·0	−1·1	0·0215	0·0214
		$KCl + \frac{1}{2}Na_2SO_4$.			
0·5	370·9	380·0	−2·4		
	436·9	446·7	−2·2	0·0222	0·0225
1	677·9	697·2	−2·8		
	794·4	815·1	−2·6	0·0215	0·0218
2	1183·6	1249·3	−5·3		
	1389·0	1455·1	−4·6	0·0217	0·0219

TABLE B.

M.	10^6k at 18° and 26°C.	Mean.	D.	$\frac{\Delta k_{22}}{k_{18}}$	Mean.
		$3MgSo_4 + 1(NH_4)_2SO_4$			
1	347·3	360·2	−3·6		
	409·8	424·1	−3·1	0·0225	0·0226
1·5	456·6	481·8	−5·2		
	540·4	567·0	−4·7	0·0227	0·0227
2	541·7	581·8	−7·0		
	640·3	683·6	−6·3	0·0228	0·0228
2·5	602·2	659·8	−8·7		
	712·9	777·4	−8·1	0·0230	0·0235
		$MgSO_4 + K_2SO_4$.			
0·5	259·2	267·0	−2·7		
	305·7	314·5	−2·8	0·0221	0·0224
1	450·9	472·1	−4·5		
	529·0	554·0	−4·5	0·0216	0·0220
		$3FeSO_4 + 1(NH_4)_2SO_4$.			
0·5	192·3	196·9	−2·3		
	225·8	230·9	−2·2	0·0217	0·0217
1	324·7	339·7	−4·4		
	381·3	397·5	−4·1	0·0218	0·0213
2	508·1	552·0	−8·0		
	597·0	645·6	−7·5	0·0219	0·0218
3	623·2	705·9	−11·8		
	739·2	825·1	−10·4	0·0233	0·0222
		$NiSO_4 + K_2SO_4$.			
0·5	246·4	256·2	−3·8		
	290·5	301·6	−3·7	0·0224	0·0225
1	424·4	455·6	−6·8		
	501·5	533·4	−6·0	0·0227	0·0214

it may be inferred that though all the four possible salts exist in each of these two mixtures, NaCl and K_2SO_4 exist in larger quantity than the other two,

Conductivity of Double Salts.

The double salts experimented on were $MgSO_4 + (NH_4)_2SO_4$, $MgSO_4 + K_2SO_4$, $FeSO_4 + (NH_4)_2SO_4$, $FeSO_4 + K_2SO_4$, $NiSO_4 + (NH_4)_2SO_4$, $NiSO_4 + K_2SO_4$, and such mixtures as were capable of forming these double salts. The accompanying table B gives some specimens of the results obtained.

These figures show an essential difference between double salts and mixtures, as with the double salts the value of D may attain as high a value as 11 or even nearly 12. This distinction exists even in cases where the dissociation is admitted to be complete, but is most marked in the case of double salts which can exist as such in solution.

This difference must depend on the chemical constitution, and it is simply explained by the hypothesis of a partial dissociation. Also as in the case of simple salts and mixtures it was found that when the strength of the solution increased complex molecules were built up, which in their electrolytic action resembled single molecules; and naturally this will occur still more in the case of double salts.

The fact of the variability of D, generally speaking proportional to *m*, shows that in the mixtures there was a partial and not a complete formation of double salts. In the case of double salts which do not undergo decomposition it would be expected that the values of D would be much higher. The example selected by the author is the double salt $CdI_2 + 2KI$, which has been shown by Hittorf not to undergo decomposition in solution unless the solution be very dilute, and he gives the accompanying table, calculated from the results of Grotrian (*Wied. Ann.*, Vol. XVIII., p. 177, 1883) and those of Kohlrausch already referred to. The last number in the third column was not an observed value, but was obtained by interpolation :—

M.	10^6k_{18}	Mean.	D.
0·5	228	291	−21·6
1	415	559	−25·9
2	758	1059	−28·4
3	1070	1484	−27·9
4	1341	(1830)	−26·7

When the solution is fairly strong D remains pretty constant, but when very dilute, complete dissociation takes place, and Grotrian estimates the molecular conductivity of K_2CdI_4 to be very approximately the sum of the molecular conductivities of KI and $\frac{1}{2}CdI_2$.

Conductivity at Higher Temperatures.

It was generally found that the deviation D of the conductivity from the arithmetic mean at the temp. 26° was slightly smaller than or equal to the value of D at the temp. 18°. In some cases, however, there was a greater difference, but not enough to warrant any inferences being drawn from it. A special determination was therefore made of the conductivity of a solution (m = 3) of ammonio-sulphate of iron at a temperature of 40°, and the value of D was found to be 9·5, its value at 18° being 11, leading to the conclusion that dissociation increases with increase of temperature, as was to be expected for mechanical reasons.

Mixtures of Simple and Double Salts.

Observations were made on some mixtures of simple and double salts in which the solutions were not in equivalent proportions. If the previous conclusions be correct, a small deviation would be expected from the arithmetic mean between the conductivity of the simple and that of the double salt. This was found to be the case, as is shown in the original paper, by a series of tables analogous to the previous one, of which examples are given above.

Results of the Research.

1. The conductivity of a dilute solution formed by mixing two salts, whether these salts be capable of double decomposi-

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tion or not, is approximately equal to the arithmetic mean of the conductivities of the two salts whose existence in the solution is most probable.

2. Inversely, from the conductivity of the mixture, the two salts chiefly existing in it may be inferred.

3. The conductivity of a dilute solution of a double salt is very slightly less than the arithmetic mean of the conductivities of its two constituents. This difference increases with the concentration of the solution, being very nearly proportional to the number of molecules.

4. Double salts are completely dissociated in dilute solutions, and more or less in concentrated solutions. The dissociation always increases with the dilution.

5. Dissociation is favoured by heat.

ON THE ELECTROLYSIS OF SALTS.

By A. RENARD, *Comptes Rendus*, Vol. CII., February, 1886.

In a note to the French Academy (*Comptes Rendus*, Vol. CI., p. 747) in October, 1885, the author called attention to the fact that if solutions of various degrees of concentration containing quantities of metal proportional to their equivalent atomic weights are subjected to a current of the same E.M.F., there is in general no simple relation between the quantities of metal deposited; and described experiments, which led him to the following conclusions:—

1. In sufficiently dilute solutions the quantity of metal deposited is proportional to the strength of the solution.

2. The quantities of metal deposited are in the same ratio as their equivalent atomic weights.

3. According to Faraday's law, the quantity of metal deposited being proportional to the strength of the current, the conductivity of the solutions containing equivalent atomic weights of the metals is the same, as M. Bouty has shown by a direct method (*Ann. de Chim. et de Phys.*, Vol. XIII., p. 433).

The current was obtained from a thermopile, by which a constant E.M.F. could be maintained for several hours. The electrodes were formed of two discs, having a surface of 226 square mm., immersed vertically in the liquid, and having their non-opposed faces covered with an insulating varnish, which was not acted on by acids. The positive electrode was made of the same metal as that in the solution, and was provided with a screw adjustment, by which it could be moved backwards or forwards through a measured distance. The negative electrode was of platinum, and was fixed to the hammer of an electric bell in order to give it a rapid backward and forward motion with the object of always having it in contact with a fresh surface of the liquid, and more particularly to ensure that the deposits should not be pulverulent, as is the case in dilute solutions where the electrodes remain fixed.

The length of an experiment varied from one to five hours, according to the quantity of metal deposited. After each experiment the electrode was taken out of the bath, washed, dried, and weighed, the increase in weight giving the amount of the deposit. Throughout the experiments the distance between the electrodes, when at rest, was 2cm., the temperature was 16 degrees, and the electromotive force of the current was 3·65 volts.

The solutions contained equivalent atomic weights of the different metals, varying in strength from 1/10,000 to 1,024/10,000 parts of metal to 100 of liquid. Salts of silver, copper, zinc, and cadmium were used in the experiments.

In the present paper the author describes the results of some further experiments made with the same apparatus upon some solutions of the same metallic salts as previously, varying in strength from 2/10,000 to 64/10,000, and containing, as before, equivalent atomic weights of the different metals. Using the same E.M.F. as before, with the same electrodes at the same distance, the author found that when the temperature varied the quantity of metal deposited increased proportionately to the temperature, according to the formula,

$$P_t = P_o (1 + Kt),$$

in which K increases as the concentration diminishes, attaining a maximum value of about ·052 when the solutions become so dilute that the quantity of metal deposited at a constant temperature is proportional to the strength of the solution.

When the distance between the electrodes was varied it was found that as the distances of the electrodes were successively doubled, the quantities of metal deposited diminished in a geometrical proportion having for its common ratio $r = 1{\cdot}237$. For distances beyond 32cm. this law is no longer applicable, as the values of r then increase with considerable rapidity.

Some experiments made with nitrate and sulphate of copper, and with copper discs as electrodes, with diameters of 10cm., 20cm., and 30cm. respectively, at a fixed distance of 2cm., led to the conclusion that when the two electrodes are identical the quantities of metal deposited are proportional to their diameters, and therefore to the square roots of their surfaces.

REPORT OF THE COMMITTEE ON STANDARDS OF LIGHT.*

BY PROF. G. FORBES.

The first communication that I have to make is the report of the Committee on Standards of Light. The Committee on Standards of Light have met repeatedly during last winter. It had been proposed in last year's report to carry on experiments on electrical standards in the hope of arriving at an absolute standard of light. One of the first steps was to discover a means of reproducing a definite temperature, and certain experiments were proposed for this purpose. At one of the first meetings of the committee Captain Abney announced that he had already found a means of doing this in a different manner to that proposed in the committee's report, depending only on the change of the resistance of the carbon filament with temperature. Under these circumstances, the committee left this part of the experimental investigation to be reported upon by Captain Abney. His further researches, however, have led him to believe that the law which he had announced to the committee does not hold with all qualities of carbon filaments. He has, however, been engaged upon further experimental researches in the same direction, which are ready for publication, and which have an important bearing on the labours of the committee. (I may here mention, however, that he has been prevented from putting these into a form ready for publication, and that must be delayed for the present.) In the last year's report attention was drawn to the value of the pentane standard of Mr. Vernon Harcourt as a practically reproducible standard of illumination. Mr. Rawson has been engaged during the past winter, under the direction and with the assistance of Mr. Vernon Harcourt, in a further examination of this standard, and his results will be made known in a separate paper. Sir James Douglass has also made some experiments which are not quite completed, but they have gone so far as to give great promise. Some account of those experiments in this report had been expected by the committee, but the absence of Sir James Douglass on official business prevented him from completing it. At one of the first meetings of the committee the secretary showed what he had done in the way of improving thermopiles, such as it was hoped would be of use in the investigation recommended in last year's report, and he was instructed by the committee to proceed with the construction of the instrument, which has been completed, and is placed before the section and described in a separate paper. The committee respectfully request to be re-appointed, with a grant of £25.

THERMOPILE AND GALVANOMETER COMBINED.*

BY PROF. G. FORBES.

My next duty is to bring before the section some account of an apparatus, a name for which I have not succeeded in fixing upon, but which I have spoken of as a combined thermopile and galvanometer, and that represents accurately what the instrument really is. A "thermal galvanometer" might perhaps be a suitable term for the instrument, the object of which is to measure the radiation of heat in the manner which has been accomplished by the ordinary thermopile. The instrument was designed more particularly for use in spectroscopic work—that is to say, to replace

* Paper read before the British Association at Birmingham.

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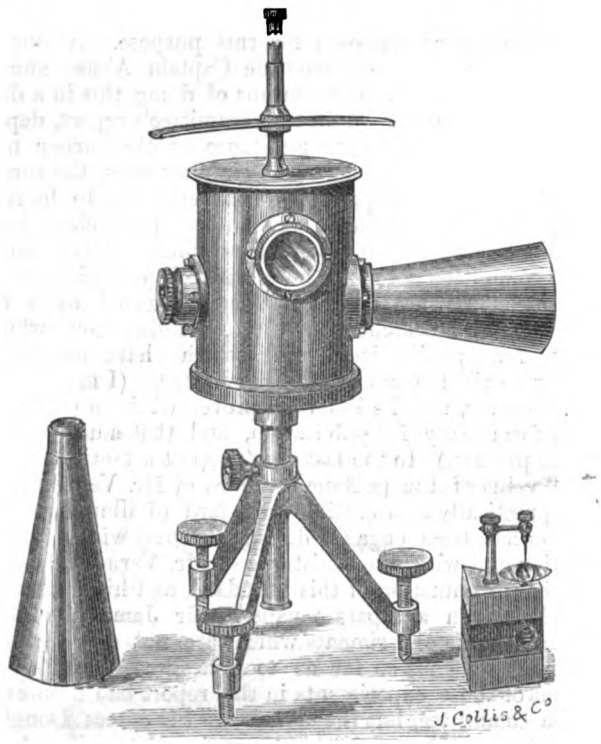
what has been generally known as the line thermopile, a thermopile which measures the intensity of light forming a linear image. Some account of the first forms of this instrument was given to the Royal Society last spring. Since then the instrument has been modified, with the intention of making it more sensitive. The first apparatus which was constructed was extremely simple, and consisted merely of a very short tube made of two different metals. One half of the circular section was of bismuth, and the other half was of antimony. The two edges were filed down, so as to be very thin, and covered with a carbon surface which absorbed radiation freely. The difference of intensity of radiation on the one junction or the other determined the direction of the electric current which circulated round the composite tube. The circuit needle had an extremely low electrical resistance, and the compass needle, or magnetic needle, like those employed in Sir William Thomson's galvanometers, was inserted into the tube, and acted directly upon this circuit of low resistance carrying the electric current. It was hoped by thus lowering the resistance enormously that we should get an increased effect, and the result of the experiment seems to support the theoretical conclusion. In the ordinary thermopile



Prof. Forbes's Combined Thermopile and Galvanometer.

as used we have a number of junctions—a number of pieces of antimony and bismuth—joined together in series, and consequently they offer a much larger resistance than the composite tube which I have spoken of. Moreover, they have the resistance of the galvanometer in the circuit, and in the communication to the Royal Society it was pointed out that one would expect *à priori* that the combination of the galvanometer and thermopile would be about equal in efficiency to this combination if the galvanometer were made specially of a proper resistance and construction for the thermopile, a thing which is seldom attained in actual practice. The form of instrument which was most complete, which I showed to the Royal Society, consisted of a wedge of antimony and bismuth combined. This [showing instrument] is not an exact representation of the wedge, but it is near enough to it to show you the type. You see this is a wedge with a hole passing through very close to the narrowest surface of the wedge. In that hole the magnetised needle and suspended mirror were placed. The upper half of the wedge consisted of antimony, and the lower half of bismuth, and the heat striking the junction of these two determined the electrical current which influenced the needle. That apparatus was found to be very sensitive indeed, and probably as sensitive as any arrangement could be for use as a line thermopile. There was one very great point about it—that it was very dead beat in its action. This large mass of metal, with its low resistance, acted as a damper on the motions of the magnetic needle, and rendered it extremely stable, and caused it to come to rest very rapidly. That was assisted, of course, by my employing in that instrument one of the mirrors of Mr. White, of Glasgow. And speaking of mirrors, I cannot conceive of anybody using any other kind in galvanometers, though in England there seems to be a delight in those heavier mirrors which are supplied by London makers. But I must say—it may be that I have had more experience of them than others—I cannot conceive anybody using others when they can get Mr. White's. Since then I have modified the instrument to make it more sensitive by making it astatic. Instead of having one set of magnets inside the circuit I have another set outside on the same suspension. The instrument is rendered much more sensitive, but it is not so dead. This wedge is enclosed in a brass covering, and it has a cone to reflect the heat on to the surface of the junction of the two metals, and it has also a controlling magnet like the ordinary Thomson galvanometer that we so often see. In the present arrangement I have put the magnet down as low as possible to give it very great directive influence, because in this room there is so much tremor that it is almost impossible to see the action of the apparatus. At this moment you notice that the spot of light has gone to the far side of the scale, and I hardly like to move it, because in doing so I should set up vibrations which would last a long time. The heat of my hand, placed beside it, is sufficient to move it over a very considerable range, but in this present shaky condition I am afraid it must be left for a limited number of gentlemen to examine it when the conditions are more favourable. I will not take up the time of the section longer than just to add that this apparatus has been made by Messrs. Nalder Brothers, Westminster, and it strikes me as being very much more beautifully made, and much more delicate, than the apparatus which I showed originally.

DISCUSSION.

Prof. FITZGERALD said he would like to ask a question as to the relative delicacy of thermopiles and bolometers. Prof. Langley, he thought, had given the preference to the latter for the purpose of measuring the current Was that the opinion of Prof. Forbes ?

Prof. FORBES said he quite agreed in that respect with Prof. Langley, believing that there was not the slightest doubt that the bolometer was very much more accurate than any thermopile arrangement. It was simply in comparison with thermopiles that he considered his instrument the most sensitive.

Lord ROSSE thought that this was a most important question to raise. He had directed his attention to it, and had endeavoured to ascertain the respective merits of the bolometer and thermopile. It seemed to him, however, on looking over Prof. Langley's paper on the subject, that the advantages attributed to the bolometer by him were rather exaggerated. Prof. Langley did not draw sufficient attention to the fact that he took immense pains to make his galvanometers. He made the needle very much lighter upon the same principle that Prof. Forbes was very anxious to make it lighter, and he made it particularly dead-beat by a very simple and ingenious contrivance, using dragon flies' wings, and thus getting a very stiff and light damper. He (Lord Rosse) tried the same thing himself on a galvanometer ; he stuck two dragon flies' wings on the back of the reflector by means of a small piece of wax ; he then stuck two more wings at the ends of the others, and found that the galvanometer was driven to the end, stopped, and returned very fast to zero. It was extraordinary how it was brought to rest after two or three oscillations. Prof. Forbes used a modified form of thermopile, but the ordinary thermopile had a number of advantages. It struck him that probably the E.M.F. was proportional to the elevation of the temperature, and by sending all the heat into one solder ten times the temperature would be obtained for the same E.M.F. By this arrangement the resistance of the thermopile was very much reduced at once. He thought that the subject wanted fuller consideration. The plan by which he collected all the heat into one solder was by fixing one solder to the other by a thin sheet of copper coil, and he believed that very rapidly carried all the heat of the disc on to the central solder. As regarded the combination of the the two which Prof. Forbes had shown, it depended upon circumstances whether the arrangement would be a successful one or not. He himself used a thermopile placed in the focus of his reflector, and employed very large wires. For his purpose it was much more convenient to read the galvanometer in the observatory, and to have it more generally used by moving the telescope.

Lord RAYLEIGH said that he would like to offer a word or two on the comparison between the thermopile and bolometer. He was very much of the opinion shared by Lord Rosse, that a great part of the important results that Prof. Langley had obtained was due more to his galvanometer and the other part of his arrangement than to the substitution of the bolometer

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for the thermopile. He would not say that the thermopile was as good as the bolometer as a general proposition. Taking the case in which interest was probably greatest, where a linear element was wanted to investigate the spectrum with, in the nature of the case, even where the apparatus was capable of taking in a considerable area or section, the ground of the spectrum would prevent it being done. They must make a comparison between what E M.F. would result from change of fine wires and the E.M.F. which would be generated by the induction at the same temperature of a single thermal element formed by putting together two equally fine wires in such a manner that the junction came into the field of action. The comparison could not be made in any absolute way, because theoretically the sensitiveness of the bolometer might be increased without limits, if they could indefinitely increase the limits passing through it. Prof. Langley did not give any definite data to enable one to fix the limit of the current that passed. In the thermopile the E.M.F. was proportional to the increase of current absolutely ; in the bolometer it was proportional to the varying influence of the platinum or whatever might be used. But, taking such data as Prof. Langley gave, it did not appear that much more E.M.F. was got out of the elements forming the bolometer than might be done out of the German silver and iron connection formed of two correspondingly thin wires. He had also tried the plan of using a comparatively small disc, and he thought that as good a result was got in that way.

Lord Rosse said he would like to add that Prof. Langley contrasted his experiments with his (Lord Rosse's), but that gentleman overlooked the fact that he (Lord Rosse) had a much larger mirror to work with, and worked in the open air in varying atmospheric conditions, whereas Prof. Langley worked in his observatory, completely sheltered from draughts of air. This fact made such an important difference that one could hardly compare the two sets of radiation experiments.

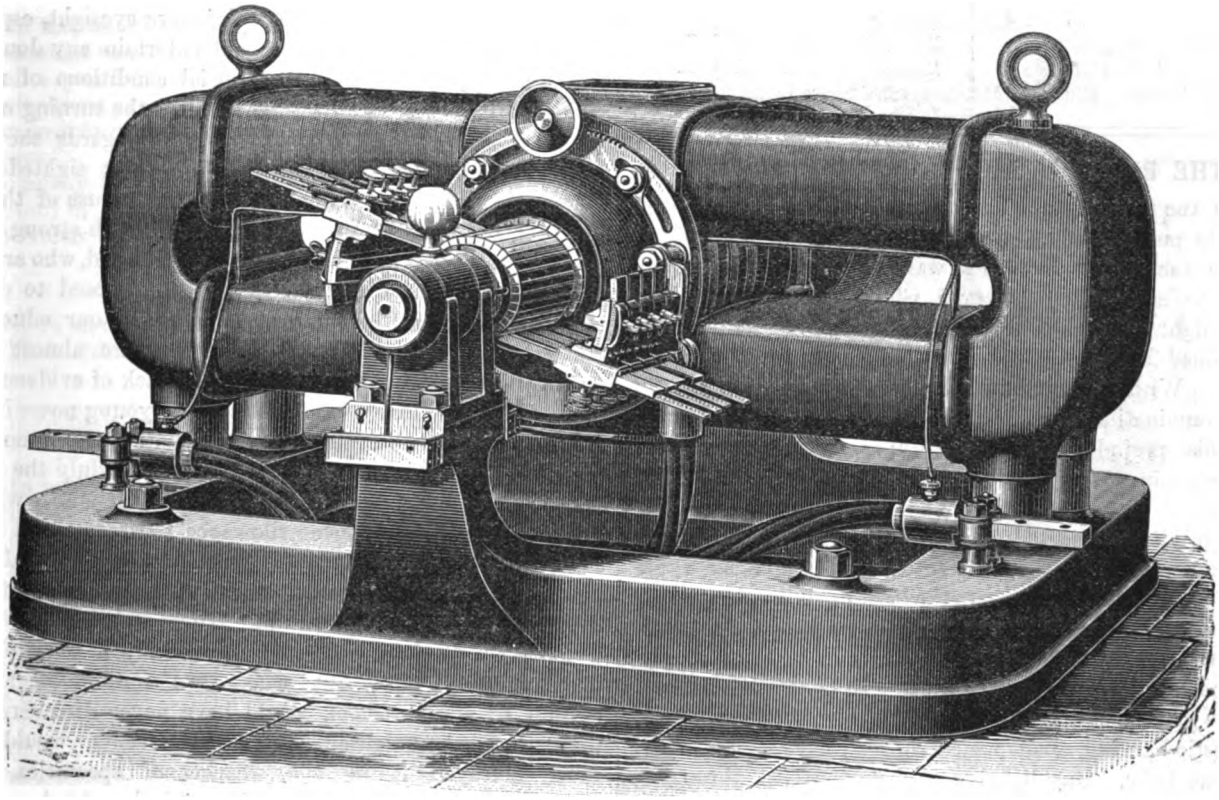
THE CHAMBERLAIN AND HOOKHAM DYNAMO.

We have already described the electric lighting of the Bingley Hall Exhibition, which was very successfully carried out by the Gülcher Company. Among the most interesting of the electrical exhibits in the body of the hall we noticed a dynamo machine of a new type, which has been designed and constructed by Messrs. Chamberlain and Hookham. The general construction of this machine will be understood from the accompanying engraving, which represents a 30-unit type. The heavy yokes and pole pieces are of cast iron, the magnetic circuit is well isolated from the frame, giving as a result great symmetry of field. The armature is of the drum type, with slots and projections similar to those of the Pacinotti ring. The armature resistance is remarkably low, being less than three per cent. in a 10-unit and less than two per cent. in a 30-unit machine. The slots and ribs of the armature are so proportioned that the sum of the sectional areas of the ribs at any time opposite the pole pieces are equal to the magnetic section of the armature, so that but for the small clearance necessary between the ribs of the armature and the pole pieces the magnetic circuit is complete through iron producing a great intensity of field.

The brushes, which are of a new type with end pressure, only require the readjustment of a spring at long intervals to compensate for wear. A brush of this kind has been on one of the company's plating machines in daily use for six months without touching. Each machine has two or more brushes side by side, and each brush is capable of independent movement, both in the direction of its length and also round the axis of the commutator.

The bearings of these machines are exceptionally long, and the steel spindles very strong and heavy, and in all other mechanical respects the machines seem to be thoroughly well designed.

The 10in. by 13in. 25-unit nominal is the largest machine on view. It is shunt wound. The resistance of the armature is ·003 ohm hot, of the magnets 8 ohms. The speed is 960 revolutions per minute, and the E.M F. 57 volts. The total energy converted is 26,635 watts. 610 watts are absorbed in the armature coils, thus giving a loss of 2·28 per cent. in the armature, 1·4 per cent. in the magnets, and an electrical efficiency of 96·3 per cent. This particular dynamo is one of a set made for use in copper refining. For ordinary electric lighting its speed would be 1,000 revolutions per minute, and we are informed that it would then develop 30 units with a still higher efficiency. A 7¼in. by 9in. 9-unit nominal dynamo is shown running as a motor by current from the Gülcher Company's dynamos which are lighting the hall. This machine is identical with the one the company have just used in their installation at the Birmingham Art Gallery. The machine has an armature resistance of ·01 ohm hot, and at 1,250 revolutions per minute gives an E.M.F. of 57 volts at terminals, and has an electrical efficiency of 94·5 per cent.



Chamberlain and Hookham's Dynamo.

The firm also exhibit their patent interchangeable wall couplings and lamp holders, which are extremely simple, and make at the same time a thoroughly good electrical and mechanical connection.

An automatic switch for use in charging storage batteries and heavy current switches of novel design are also shown.

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THE ELECTRICIAN.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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THE ELECTRIC LIGHT AND EYESIGHT.

One of the first objections to the Electric Light when introduced into public buildings was on the score of its being so trying to the eyes. Even its warmest admirers were constrained to admit that however wholesome might be this artificial light in regard to the atmosphere, the natural eye was strained and rendered somewhat uncertain under its influence. With the gradual disappearance of arc lights for indoor illumination, and the substitution of incandescent lamps, this prejudice is rapidly dying away. It is kept alive in certain places, such as the British Museum Reading Room, whose late visitors pay the penalty of a headache for the privilege of studying after ordinary hours. But in the Theatres, where the more agreeable and steadier application of electricity was adopted, the light has been always very popular, and, so far as we know, has never been objected to either on the ground of its being defective as a light, or prejudicial to the complexion considered as a decorative adjunct. The same may be said of it wherever it has been introduced for domestic lighting, about which we shall have more to say in our next issue. Gas lighting probably passed through a similar experience before burners and globes were interposed to regulate and modify the coarse and turbulent flame of blazing gas. The arc light is to the incandescent light what the flare of a gas tube is to the glow of a well-fitted gaselier. And, as regards the eyesight, unprejudiced observers have uniformly given their verdict in favour of the improved electric lamp over the best form of gas burner.

We are led to making these observations on perusal of a paper read by Dr. Oakley at the Congress of the Sanitary Institute held at York last week on the Prevalence of Defective Eyesight. Not that Dr. Oakley made any special reference to the Electric Light in relation to what he testifies is a growing defect among the people of this country. But the importance of the subject and its connection with the question of lighting are obvious; and in the solution of this question we believe the Electric Light will in the future take a conspicuous place. Defective eyesight is in part produced by insanitary conditions and hereditary tendencies transmitted under their influence. One at least of these baleful conditions would be removed by the relegation of gas to the place where we have already banished the arc light, namely, out of doors. Dr. Oakley speaks very precisely as to the effects of vitiated atmosphere and high temperatures in crowded places as the predisposing causes of defective sight and hearing; and most people can corroborate him to some extent from their own experience. Hot eyelids and aching head, followed by chill and slight catarrh, are commonly the effects of incautious enjoyment of pleasure where a dazzling blaze of gaslight forms part of the evening's attractions; and this form of attack, often repeated, is, we are told, far more prejudicial to the eyes than any ordinary cold, however severe, could possibly be. On the other hand, insufficient light is a fruitful source of impaired eyesight. But insufficiency is of two kinds; either it may be inadequate in quantity or defective in quality. Young people are never discriminating in these respects, and sustained exertion of the eyes is often persevered in without suspicion of harm. Upon their elders devolves the obligation to guard against permanent injury to the most precious of all human possessions; and Dr. Oakley gives some very useful hints well worth attending to in these days of educational high pressure.

Of the growing prevalence of defective eyesight, especially of myopia, nobody, we imagine, will entertain any doubt. It is due partly, no doubt, to the artificial conditions of modern civilisation, among which we must reckon the turning of night into day one of the foremost. But as regards the rising generation, Dr. Oakley attributes its short sightedness to increasing pressure of schooling, to excessive use of the eyes for near objects, and to close application with strong mental effort in early life. On children already debilitated, who are badly nourished, and who are hereditarily predisposed to disease, the effect of schooling under the latest of our educational crazes is simply disastrous. Medical men are almost agreed on this point; and there is certainly no lack of evidence to go upon. The prevalence of spectacles on young noses in these days is a fact which cannot escape the notice of the most careless observer. We have no desire to press unduly the natural inference to be drawn. No doubt it is very generally what the doctors say it is; but some allowance must be made for the equally undoubted fact that a great number of children are now undergoing a course of education who formerly would have had no education at all. These scholars are mostly of the lowest orders, who are presumably most subject to the hereditary taint, but who, save for the legal compulsion to attend school, would have never discovered that they were short sighted—or, at all events, would have never betrayed it by the wearing of spectacles. They are probably made worse in this particular by learning to read and write; and the hereditary defect will be transmitted forward by them in an aggravated form. Whether we gain much by filling the brain and emptying the eyes is a question which is open to dispute; but there is no denying the fact that the general tendency is to create and perpetuate a blind race, who left to themselves might have preserved their eyesight, and under less artificial conditions might recover its full enjoyment.

As a nation we are better sighted than the French, and immeasurably superior to the Germans, though we cannot pretend to be the superiors of the latter in physique. The case

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of Germany confirms the doctors' view. We hardly exaggerate when we say that too much learning has made the Germans blind. It is rather a distinction to wear spectacles—or, rather, a mark of inferiority not to wear them. But the practice is more common among the better classes than among the lower. The village youth becomes a "somebody" if he can anyhow make believe to need the assistance of a pair of *pince-nez*, which is a sign of learning as irrefragable as the goggles of an Oriental. Something, however, must be laid to the charge of a barbarous type when accounting for Teutonic myopia; and this is perhaps the reason why the educated classes—by which we mean the student classes—are more grievously afflicted than are the artisans and rustics. We are better off in this respect than our German neighbours, but their experience ought to be a warning to us against undue pressure of the very young at our Board Schools. Home lessons, Dr. OAKLEY states, are a fruitful cause of impaired eyesight; and the Germans are excessively exacting in home lessons. It will be long before the Electric Light will help the ordinary scholar with his books; but everything that tends to establish a higher standard of illumination will gradually improve the national health, and is calculated to preserve the people's eyesight.

CORRESPONDENCE.

THE TELEPHONE IN SMALL TOWNS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In last week's impression (page 400) it is mentioned that you cannot recall a single instance in this country of a town with a population of less than 10,000 being provided with a telephonic exchange. I am pleased, however, to be in a position to inform your readers that there are several such "exchanges."

My company has opened three (Ormskirk, Skelmersdale, and Huyton) in Lancashire, and several others in the little towns of North Wales.—Yours, &c.,

KENNETH MACIVER,
Secretary and General Manager.

Lancashire and Cheshire Telephone Company,
Manchester, 25th September, 1886.

EFFICIENCY TESTS OF DYNAMOS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reference to the note in your issue of Sept. 17 on the testing of dynamos, I wish to remark that a method of testing, *only by electrical measurements*, was already indicated by me in my letter of March 15, published in your issue of March 19, 1886.

I think my method is preferable in respect to accuracy and simplicity, as it does not depend on the assumption that the efficiency of a dynamo is the same as a motor or as a generator, which is certainly *not* "absolutely beyond suspicion of error."

In my method *two tests* are sufficient, no matter if identical or different size or type of dynamos are used, while in the manner as indicated by Mr. Trotter, in your issue of Sept. 24, *six tests* must be made.—Yours, &c., C. L. R. E. MENGES.

The Hague, Holland, September 27, 1886.

[We would point out that the method described by our correspondent in his letter of March 19th can scarcely be said to depend *only upon electrical measurements*, inasmuch as the efficiency of the motor must in this case be previously determined by means of a dynamometric brake. The formula contained in the letter of Mr. A. P. Trotter upon this subject, and which appeared in our last number, owing to a slip of the pen on the part of the writer, stands in need of correction. It should read

$$A = \sqrt{\frac{E_2 E_3}{E_1}}.$$

—ED. *E.*]

A NEW SCALE FOR TANGENT GALVANOMETERS.*

BY W. H. PREECE, F.R.S., AND H. R. KEMPE.

Tangent galvanometers are much used for the exact quantitative measurement of currents of considerable strength, such as are measured in amperes, but they are not so generally used for the measurement of smaller currents in milliamperes. This arises from a notion that they are not sensitive enough, although the most sensitive instrument in practice—Sir William Thomson's mirror galvanometer—is really a tangent instrument. The ordinary forms, Joule's, Gaugain's, or Helmholtz's, are not very sensitive. Their constant is about 3; that

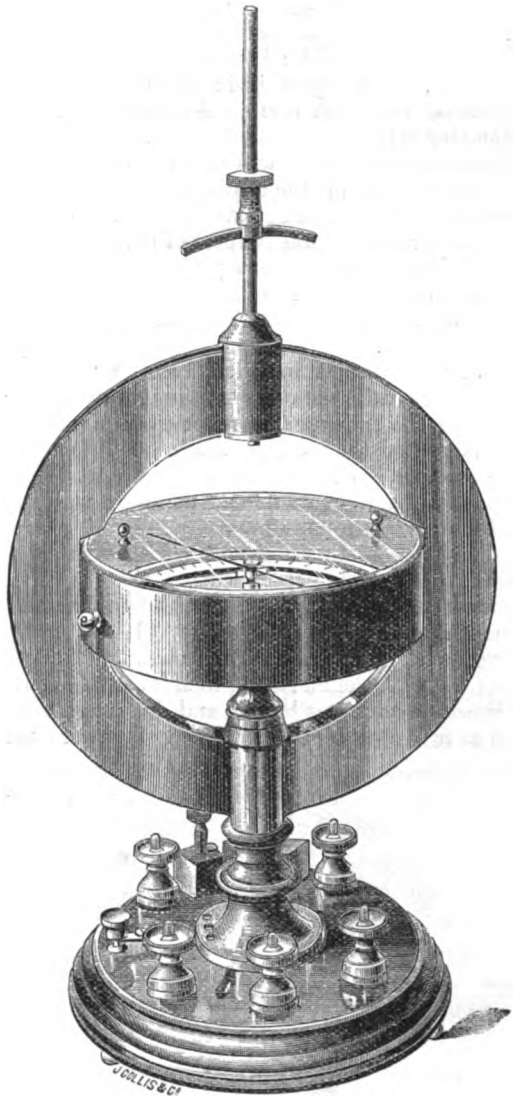

FIG. 1.

is, 3 amperes are required to produce the unit deflection of 45°. The Post Office has for many years used a more sensitive and portable form, having a constant of ·00214, for testing wires, batteries, and apparatus Fig. 1 shows in elevation the

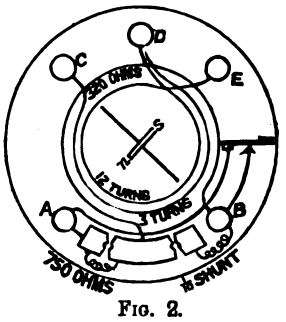

FIG. 2.

general form of the instrument; Fig. 2 is a general plan of the arrangement of the coils, &c.

* Paper read before the British Association at Birmingham.

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The ring, which is 8in. in external diameter, has three coils of wire wound on it. The one nearest the needle is of No. 35 wire, and is wound to a resistance of 320 ohms approximately. The other two coils are of No. 18 gauge; the one between C and D making three turns, and the one between D and E making 12 turns in the opposite direction. The latter coils are for testing batteries; by using terminals C D, D E, or C E, respectively, relative degrees of sensitiveness of approximately 1, 3 and 4 can be obtained. An adjusting magnet, similar to that used on the ordinary Thomson mirror galvanometer, is set on the upper part of the ring, as shown. In testing the strength of a current in milliamperes by means of the instrument a standard Daniell cell is connected between terminals A and B; both plugs being removed from the plug holes, *a*, *b*, there is in circuit a total resistance of 1,070 ohms, viz., 750 + 320. As the electromotive force of the standard cell is 1·07 volt, the resulting deflection (30°) of the galvanometer needle will be due to a current of 1 milliampere. By means of the adjusting magnet this deflection can be increased or diminished as required. In practice, the adjustment is such that 1 milliampere of current gives a deflection of 80 divisions on the ordinary tangent scale. When the measurement of a current is to be made the plug in *a* is usually inserted so as to cut out the 750 ohms resistance. Plug *a* inserts a $\frac{1}{10}$th shunt.

Hitherto *two* scales have been engraved on the dial, the one divided in degrees and the other in tangent divisions; and to avoid parallax the indicator is reflected in a mirror, so that when the image and the indicator are in one line no error from this cause occurs. Where observations are made by reading deflections serious errors arise from parallax, especially where the law of tangents is followed.

Mr. Eden—one of the assistant electricians of the Post Office—discovered, while experimenting, that the galvanometer could be made more sensitive to increments of current for high deflections if it were given a false zero. In fact, if the instrument be "slewed" round so that the plane of the coil makes an angle of 60° with the meridian, then the instrument becomes twice as sensitive as it was before, and he suggested a double scale such as is shown in the following figure to utilise this

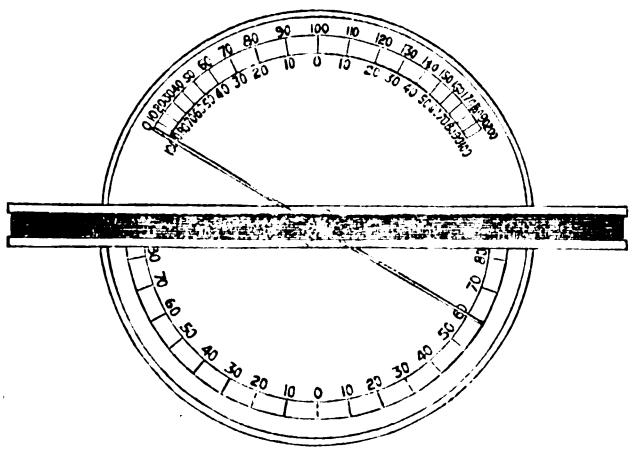

Fig. 3.

fact. This plan has been adopted, and all tangent galvanometers in the Post Office service will be gradually altered to the new scale.

It is quite clear that the instrument owes its increased sensitiveness to the fact that when the needle reaches its maximum deflection, its angle to the lines of force of the field is the one most favourable for the deflection of the needle by the current. In fact, the plane of the coils becomes parallel to the plane of the needle, which is then in the most *uniform* portion of the field

It becomes most desirable to know if the divisions of deflection under these conditions are still proportional to the current strengths.

Let the dotted line A, B, represent the plane of the coil ring, and let a_1, b_1, be the needle which has been deflected from the normal position, *a*, *b*, the angle which the needle normally makes with the coil being $\beta°$. Let $\alpha°$ be the angle to which the needle has been deflected to the other side of the coil, then

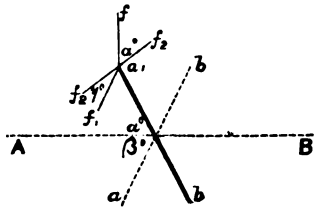

Fig. 4.

deflective force, *f*, of the coil resolved at right angles to the needle is

$$f_2 = f \cos \alpha° \, k$$

where *k* is a constant.

Also force f_1 of earth's magnetism, which acts parallel to *a*, *b*, resolved at right angles to the needle is

$$f_2 = f_1 \cos \gamma° \, k$$

therefore $$f \cos \alpha° = f_1 \cos \gamma°$$

or $$f = f_1 \frac{\cos \gamma°}{\cos \alpha°}$$

but $$\gamma° + 90° + \alpha° + \beta° = 180° \therefore \gamma° = 90 - (\alpha° + \beta°)$$

from which $$\sin \gamma° = \sin (\alpha° + \beta°)$$

therefore

$$f = f_1 \frac{\sin (\alpha° + \beta)}{\cos \alpha°} = f_1 \frac{\sin \alpha° \cos \beta° + \sin \beta° \cos \alpha°}{\cos \alpha°} \text{(A)}$$

$$= f (\tan \alpha° \cos \beta° + \sin \beta°) = f \cos \beta° \left\{ \tan \alpha° + \frac{\sin \beta°}{\cos \beta°} \right\}$$

$$= f \cos \beta° (\tan \alpha° + \tan \beta°)$$

so that cos β being a constant quantity the strength of a current is directly proportional to $(\tan \alpha° + \tan \beta°)$, which is the reading on the tangent scale if the figures on the latter are rearranged so that the zero is at the division at which the needle points in its normal position.

By thus changing the zero of the instrument the range of movement can be considerably increased; thus if $\beta°$ be the angle which the needle normally makes with the coil, and if $\alpha°$ be the angle to which the needle has been deflected on the other side of the coil, then *f* being the deflective force, we have

$$f = f_1 \frac{\sin (\alpha° + \beta°)}{\cos \alpha°},$$

when f_1 is a constant. But if the needle were parallel to the coils, then

$$f = f_1 \tan \alpha_1$$

therefore $$f_1 \frac{\sin (\alpha° + \beta°)}{\cos \alpha°} = f_1 \tan \alpha°_1$$

Now if we have $\beta° = 60°$, and if the current be sufficient to turn the needle through 2 $\beta°$ or 120°—that is, if we have $\alpha° = 60°$, then

$$\frac{\sin 120°}{\cos 60°} = \tan \alpha°_1$$

but $\sin 120° = \sin (180° - 60°) = \sin 60°$; therefore,

$$\frac{\sin 60°}{\cos 60°} = \tan \alpha°_1 = \frac{\sin \alpha°_1}{\cos \alpha°_1}$$

or, $$\alpha_1 = 60°$$

that is to say, the angle through which the needle would have been turned when the zero was 60° to one side of zero would be twice what it would be if it had been deflected from the ordinary zero. The ratio of these angles, however, decreases in value, and at a certain point becomes equal to 1; that is to say, the angular deflection from the new zero is the same as it is from the old zero.

Let $$\frac{\sin (\alpha° + \beta°)}{\cos \alpha°} = \tan \alpha°$$

therefore $$\frac{\sin (\alpha° + \beta°)}{\cos \alpha°} = \frac{\sin \alpha°}{\cos \alpha°},$$

or $$\sin (\alpha° + \beta°) = \sin \alpha°.$$

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If the angle α° is negative—that is to say, if the angular deflection from the new zero is less than the angle β°—then we have

$$\sin(\beta^\circ - \alpha^\circ) = \sin \alpha^\circ,$$

or

$$\beta - \alpha^\circ = \alpha^\circ;$$

that is

$$\beta^\circ = 2\alpha^\circ,$$

or

$$\alpha^\circ = \frac{\beta^\circ}{2};$$

that is to say, whatever be the angle β° (the angular distance of the new from the old zero), then a current sufficient to move the needle a distance of $\frac{\beta^\circ}{2}$ from the old zero would move the needle the same distance from the new zero. *If the deflection from the old zero be less than* $\frac{\beta^\circ}{2}$, *then the deflection from the new zero will be less still*, so that there is no advantage in the use of the new zero unless the deflections exceed $\frac{\beta^\circ}{2}$.

If the angle β° be made greater than 60°, then the possible angular movement of the needle becomes still further increased; but inasmuch as any increase in the length of the tangent scale brings the division at the ends of the scale proportionally closer together and more difficult to read from, there would be no practical advantage in making the angle larger. A marked advantage, under certain conditions, is found when the new zero, has such a value that the deflection from a given current causes the needle to turn up to the ordinary zero—that is to say, to the position where the needle becomes parallel to the coil; in this case the instrument becomes highly sensitive, and any increase in the strength of the current produces a very considerable change in the deflection.

Thus, supposing the new zero to be, as before, 60°, then if after the needle had been deflected to the old zero the current which had caused this deflection had increased 10 per cent., then the deflection, α°, beyond the ordinary zero would be such that

$$\tan \alpha^\circ + \tan 60^\circ = \tan 60^\circ \times \frac{110}{100},$$

or

$$\tan \alpha^\circ = \tan 60^\circ \left(\frac{110}{100} - 1\right) = 1{\cdot}7320508 \times \frac{10}{100}$$

$$= {\cdot}17320508 = \tan 9^\circ 50'.$$

If, however, the deflection had been from the old zero in the first instance, then this deflection γ° would have been such that

$$\frac{\sin(0^\circ + 60^\circ)}{\cos 0^\circ} = \tan \gamma^\circ,$$

or

$$\sin 60^\circ = \tan \gamma^\circ;$$

therefore

$${\cdot}8660254 = \tan \gamma^\circ{}_1$$

or

$$\gamma^\circ = 40^\circ 54'.$$

If the current under these conditions were increased 10 per cent., then the increased deflection, γ°, would be such that

$$\tan \gamma^\circ{}_1 = {\cdot}8660254 \times \frac{110}{100} = {\cdot}95262794 = \tan 43^\circ 37',$$

which is an increase of

$$43^\circ 37' - 40^\circ 54' = 2^\circ 33'$$

as against 9° 50′ when the deflection was taken from the new zero, an increased sensitiveness of over 4 : 1 in favour of the new zero.

If the angle β had been 85°, then an increase of 10 per cent. would move the needle as much as 48° 45′ beyond the ordinary zero. It might then seem that the greater β° is made the better; but there is a practical limit to this increase, for the larger we make β the more does the deflective action of the coil tend to act in a direction parallel but opposite to the earth's magnetism, the consequence being that the resultant of the two forces is a comparatively small quantity, and the friction of the pivot, &c., prevents the needle from settling down to the true angle representing the force of the current. Under such conditions very large errors in the readings may result. Were it not for this fact the instrument would increase in actual sensitiveness up to that point at which $\beta' = 90^\circ$, at which point the needle would not move unless acted upon by a current exceeding in deflective force the intensity of the earth's magnetism; when the current exceeded this value the needle would swing completely round through an angle of 180°.

A NEW FORM OF STANDARD SINE GALVANOMETER.*

BY J. T. BOTTOMLEY.

Mr. Gray proposes to use a coil of uniform wire laid into the thread of a screw cut with all possible accuracy on the surface of a cylinder. The absolute force at the centre of such a coil is calculated by a well known formula. In the centre of the tube is hung a short magnetic needle with mirror attached. A short scale or mark at one end of the tube is received by means of a telescope at the other end of the tube, and the whole tube is turned round on a central transverse axis till maximum deflection of the magnet is obtained and the instrument is used as a sine galvanometer.

ABSTRACT OF THE REPORT OF THE COMMITTEE ON ELECTRICAL STANDARDS.*

Eighteen stantard coils have been tested during the year and certificates of their value issued. The attention of the secretary was called to the fact that the paraffin in some of the coils showed a trace of green colouration round the edges. This has been shown to arise from the action from a small amount of acid left in the paraffin on the copper of the case and connecting rods, and the committee are considering how to deal with the difficulty. At the present the insulation resistance of the coils is extremely high, amounting to as much as 8,000 megohms. The committee wish to express their sense of the great desirability of establishing a national standardising laboratory for educational instruments on a permanent basis, and their readiness to co-operate in their endeavour to secure the same. The committee apply for reappointment, and for a grant of £50.

UNDERGROUND TELEPHONIC CABLES IN THE STATES.

At the recent Telephone Convention at St. Louis Mr. C. N. Fay read a long paper on this subject, and quoted statistics which had been furnished him by various companies in different parts of the country. The information obtained related to induction, insulation, capacity and resistance of the underground cables, and, though sometimes interesting, was, as a rule, far too fragmentary, uncertain, and conflicting to furnish any really valuable data. In general, it appears that upon short lengths and with high insulation resistance the experience of underground conductors has been fairly satisfactory, especially in those cases where some form of anti-inductive shield has been employed. In one form of cable so furnished it is stated that, although the insulation resistance is no more than 0·2 megohm per mile, yet absolutely no "cross-talk" is perceptible. The general tendency, however, in America—and one which is undoubtedly wisely directed—is towards the employment of heavier lines and higher insulation. The following passages detailing the experience of the author himself are sufficiently important to be reproduced at length. For experimental purposes Mr. Fay was able to connect together several lines which gave him a circuit "consisting of nearly three miles in cables, of which about a mile was the Waring cable underground, another mile Patterson cable overhead, and another mile Patterson cable underground. Testing these conductors by themselves last January, without connection with aërial wires at either end, we found but litle cross-talk in the new underground work, but a great deal in the old aërial cables. This fall, testing again, we find considerable cross-talk in all of those cables; we find that the insulation runs down rapidly, and is very difficult to keep up; that

* Paper read before the British Association at Birmingham.

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most of this failure is in the terminals; that as the insulation runs down the cross-talk increases; that in comparison with the old overhead systems the cross-talk is probably two or three times as great. As regards insulation the cable portion of our wires is much more highly insulated than the old aërial wires, especially as we used to run them upon porcelain knobs. We find that the paraffin cables absorb moisture at the terminals, and that it is very difficult to keep up the insulation on that account. It is true, however, that insulation of three or four hundred megohms, such as we have had at the beginning on most of our cables, might be called 'too fancy' for practical use. We are attempting to keep up an insulation on our cable work that we do not follow out throughout the switch-board, office wires, &c.

"The general result of our cable work is unsatisfactory by reason of cross-talk and indistinctness of transmission. We have spent a great deal of time and money measuring up lines, cutting out bad points and rebuilding and putting everything in shape. One of our best inspectors thinks that the indistinctness of transmission is due very largely to poor contacts in the switch-board, caused either by iron plugs which rust, or by phosphor-bronze on other contact points, which tarnish. This theory has been broached but lately, and we are now at work upon it; but I fear that the increasing use of cables is destroying the satisfactory character of telephone transmission. We expect this year to put down two miles and a half of Brooks oil cable throughout the central district, connecting our whole system together. When this is completed, a few months' use will show whether my fears are well founded; but I have serious doubts whether we can, after this year, continue further our underground extensions.

"An interesting fact is that the Brooklyn cable, a mile long, fifty wires, No. 16 gauge, shows no cross-talk. The insulation of this cable is but 27 megohms, but its resistance is also very low, 13 ohms to the mile."

Following this a paper was read by Mr. Sargent on the underground work in Brooklyn. We gave some account of the Brooklyn experiments not long since. Our readers will, perhaps, remember that creosoted wood has been adopted for the conduits, and that no attempt is made to render them watertight. This arrangement continues to give satisfaction, and the first half-mile has now been in use for nearly two years. The lead casing of the cables is, however, in many cases excessively corroded, but the valuable though accidental observation of the fact that a small admixture of tin with the lead effectually prevents the corrosive action seems now to be fully established.

THE NATIONAL ELECTRIC LIGHT ASSOCIATION OF THE UNITED STATES.

(Continued from page 414.)

The discussion which followed the reading of the paper on electro-motors (which we reproduced last week) can scarcely be said to have elucidated any points of real interest, whether of a technical or a practical character. Most of the speakers testified to the great interest which is being taken in the subject both by the electric lighting companies and by the public at large. Little or nothing was said as to self-regulation or as to the efficiency of the various types in use. Some conversation took place upon the subject of "whether arc light or incandescent light circuits are most suitable for running motors." One gentleman, who seemed to have some experience with motors run on arc circuits, or, as we should say, series-wound, wanted to know whether he could not make use of the same machines on an incandescent circuit. Up to the present time the series-wound motor has received by far the greatest amount of attention. This was to be expected, not only because arc light circuits are far more numerous in the States than circuits of constant E.M.F., but also because the problem of the series-wound motor is by far the more simple of the two. Mr. Baxter explained at some length, but in very simple language, the difficulties which would arise if a motor running in multiple arc received the full E.M.F. of the circuit while the armature remained at rest. Several members mentioned that they were using shunt-wound motors with success, but in no case did they give any further details of importance.

The following paper on wiring buildings led to a discussion of greater practical value:—

Some Features of Incandescent Lighting and Wiring.

BY MR. T. C. MARTIN.

In bringing to your attention a few remarks on incandescent lighting and wiring, it will be of interest to note that at the first meeting of the Association the first subject on the programme was "incandescent lighting." It seems to me wise that the subject should have been given such prominence. The arc light is to many of us a main object of concern, as it is a main source of income; but, after all, as Dr. Otto A. Moses pointed out so forcibly at our New York meeting last September, the arc lighting field, when wholly covered, is but 5 per cent. of the possible area over which electric current can be utilised for illuminating purposes, in cities and towns, to replace gas, oil, and candles. We are told by some that even in its own special and peculiar sphere of occupation—that of street lighting—the arc lamp is to give way before large incandescent lamps disposed, as are the gas jets, on short, ordinary posts. That may be, though I hardly expect to witness a complete change yet awhile. I know of few more cheerful or beautiful sights than the tower, like a "radiant sister of the day," as Shelley phrased it, holding aloft through storm and calm its torch of living fire; or the long lines of steadfast white stars that now begirdle and illumine nightly the finest thoroughfares of our most progressive cities. Those lights have come to stay, little as the Hickenloopers may be willing to admit it.

Meantime, the incandescent light is rapidly gaining ground, leaving its more robust brother outside, for the present, as a most unquestionable cock of the sidewalk. At the Baltimore meeting last February, Mr. De Camp summed up the situation in regard to indoor lighting in half a dozen highly significant words. He said: "The incandescent light is popular. It is growing in popularity. It is most popular among the business people." That being the case, there has been a general desire on the part of arc lighting companies to meet the demand that comes to them for both forms of the light. To the public, the electric light still means either arc or incandescent, indifferently, to be ordered at the same station, just as one would order butter and cheese at the same store counter. One effort to meet the new requirement has been made in the supply of incandescent lights on arc circuits, run from distributing boxes; and while that method is characterised by many practical men as a craze, and by others is regarded as still in the stages of experiment more or less advanced, it has the recommendation of filling a gap. Some companies are trying the system with success, while others, with deeper purses or fortified by the courage of their convictions, have put in already separate plant for incandescent lighting, and are running independent circuits for it. At the beginning of the present year, about sixty arc companies were operating incandescent lights as a regular and large part of their business, and from what I can learn, the number has doubled since then. Altogether, the late remarkable development of the incandescent field is, I venture to say, well worthy the consideration of the Association in its assemblage to-day. The chief elements of operation are now well ascertained and determined. We have dynamos of high efficiency giving us currents of constant potential, we have lamps steadily gaining in life and candle-power, and through the meetings of the Association we are quickly learning the best methods of station equipment and management. But, so far, little has been said in public or in print about wiring, in connection with which many important "details of refinement" have still to be settled. My own interest in the matter has been aroused by an inspection of some of the work done in New York, especially that of Mr. Augustus Noll, of the firm of Noll Brothers, who have put in probably more than 50,000 lights for the Edison Company, the confidence of which they deservedly enjoy. From the fact that the Edison Company has lately abolished its wiring department and turned over the work to this firm, I cannot but infer that the methods adopted have been such as to reflect great credit on the Edison system wherever thus installed. A glance at those methods, then, will perhaps be beneficial and suggestive.

Mr. Noll is an enthusiastic advocate of the "distribution" system in wiring as compared with the "circulation" system, and I am free to own that the little study I have been able to give the subject almost persuades me, too, to be a "distributionist." A definition of the two systems, or rather a statement as to their differences, may be attempted here. "Circulation," regarded broadly, consists, for instance, in a large building, in running the main wire clear through from the dynamo to the last floor, and at each floor taking off a feeder by which in turn the lamps there are supplied. Now, according to Mr. Noll, a system of this nature is very difficult to manipulate. You have naturally a large loss between the first lamp and the last, and the only way to get equal candle-power on each floor is to put in lamps of lower voltage the further they are removed. But the lower the voltage of the lamps, the less economical does the system become; the heat units on the line are increased, warming up the conductors undesirably, and as some of the lamps nearest the machine will be run above their candle-power, there will be abnormal breakage. Moreover, if the building have great depth, the lamp furthest from the main on the same floors will show a drop in candle-power as compared with the lamp on that floor nearest the main. Besides, in testing for grounds and leakages, much cutting and time are required to locate the trouble, especially where, as I have known to be the case in some large installations, as many as fifty or sixty lights have been placed under the control of a single switch.

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Turning to the "distribution" system, as recommended so enthusiastically and employed so skilfully by Mr. Noll, it would appear that a plant, no matter how large, can be wired in such wise that the loss or drop between the top floor and the basement will be as inconsiderable as only one or two volts. The idea is to wire to centres, or distributing points midway in the installation, thus equalising the pressure on all parts of the conductors, and making it possible to use the same volt lamp in the plebeian dive, the luxurious parlour, and the journalistic garret on the the seventh floor. The wires are so arranged, too, that any portion of the system may be individually disconnected and tested, and hence the cutting of wires and damage of floors and ceilings can be avoided or minimised where the wires are concealed from sight. When the building is very large, it is advisable to run two or more main feeders, as by using only one the distance from the distributing centre will be great enough to increase the drop on the line. For other reasons, too, it is always preferable to have more than one main feeder. Should any mishap occur with dynamo or engine, you can throw off one section of the building or throw in another dynamo, or where both machines supply together, leave one with the lightened load. A further advantage of frequent distributing points is, that all safety devices, such as cut-outs, switches, &c., are located on each floor in one known place or more, easy of access to those in charge; whereas in ordinary "circulation" they are placed in all parts of the building indiscriminately. To give two examples of Mr. Noll's methods: I found that in the new Astor Building, in Wall-street, a structure of great depth, he has three main circuits on each floor, with the switches and safety catches in groups of five in definite locations within the hallway panelling. Hence he could test our trouble down to any group of five, and then go without the least delay to the box revealing the actual fault. In the Central Park Plaza Hotel, where more than 3,000 lights are being installed, Mr. Noll has five main feeders connecting with five switches and boxes on each floor. The boxes are placed in the hallways just at the top of the wainscoting, and, while in nobody's way, can be got at immediately. It is evident that by locating all the control devices in lock boxes in the hallways, in hotels or apartment houses, you do not inconvenience any occupant of a room. If trouble arises, you go direct to the box concerned and test from that point. The matter of covering up wires is another point on which the Association might well utter an official opinion. In the new buildings on which he is at work, Mr. Noll has all his wires out of sight, in the walls, under the plaster and the woodwork. The effect is admirable. Yet it was but the other day that the president of a parent company in the incandescent field expressed to me his decided preference for wires in sight, that being in accord with modern architectural and engineering practice as far as he was acquainted with it. He liked mouldings; while another active worker in incandescent lighting told me not long ago that the sight of a moulding on a wall for wires was abhorrent to his ideas of beauty and seemliness. Perhaps uniformity in this respect will not be reached until, as will soon be the case, all buildings are wired from the start. Then they will be, I think, in the walls and under the floors, as are the gas pipes to-day. There are some places, however, where wires are necessarily strung in full view, such as breweries, dye-houses, stables, and like establishments, in which the air is very damp or is laden with acid vapors. I notice that Mr. Noll makes a practice in such cases of using good insulated wire suspended as much as possible, using a minimum quantity of insulators or fastenings. This should be, as perhaps it has already become, a generally adopted method.

And now, fittingly, one or two words as to the underwriters' rules and regulations. In New York it is required that wires should have 2½in. space between them, or not less than half-an-inch of some solid non-conductor, such as dry wood. When the work is finished, the company or contractor notifies the board, and an inspection is made. Now the work may be seemingly good, but should that dry wood become wet, a not unlikely contingency, any defect or shortcoming in the work would soon manifest itself unpleasantly. Again, in a new building, where wires are laid under the floors or imbedded in plaster, the contractor can in reality use any material he pleases and run the wires as his fancy or convenience dictates, for when the inspection occurs, after the work is finished, the underwriters' man has to depend rather on the evidence of his ears than of his eyes. The wires being concealed, the inspector can only know of their position and condition by some intuitive process. To step in at so late a stage is rather superfluous.

Moreover, there is a want of uniformity in system. In New York the underwriters depend for safety on the distance apart of the conductors, while in Chicago, I am informed, they depend chiefly on testing the resistance of insulation, which, not unlike the little girl of history, may be "very, very good" at one time, but decidedly "bad" and "horrid" at another. In New England, as I understand, samples of wire are given to lighting companies and wiring contractors, accompanied by rules as to which should be used and as to the nature of the workmanship. In that section more has been done, I believe, than anywhere else to secure good, honest work. Still, in a comparatively new industry there will be frequent opportunities of evasion. It is suggested by Mr. Noll, in reply to my queries on this point, that in all large cities and manufacturing centres an intelligent, trustworthy inspector be appointed, having the necessary qualifications to judge of proper mechanical and electrical construction. Then, when a building is to be wired, notification of the fact should be sent in, with samples of the wires to be used. At the time fixed for starting, the inspector should be in attendance to look over the building and offer suggestions, and from that time the work should have his supervision so that he can satisfy himself as to the standard quality of material and work. On completion, the inspector could at once issue his permit. I am not greatly in favour of inquisitorial methods of keeping mankind straight, but it is not impossible that a plan of this character would do much to raise the quality of the work, secure satisfactory operation of plant, and give greater stability to the whole business. Or, as an alternative, the step might be taken under the auspices of this association, of examining and certifying or licensing those who do the actual wiring. This is the practice with steam engineers and plumbers, yielding excellent results, and it might go far toward securing the users of electric light against inferior and dangerous work. Nothing is good enough until it is as good as it can be.

In the course of the discussion which followed, Mr. CHENEY said that his company had not found much advantage in running incandescent lamps on arc circuits. He thought it to be a dangerous practice to run wires under floors, &c., and made a strong plea for the use of mouldings.

Mr. RIDLON said that it was thought by their insurance people that an air space with the wires in sight was far better and safer than any moulding whatever. If they were to have a moulding they should have one that was fire-proof and proof against dampness between the moulding and the wall.

Mr. RHODES said that at Niagara Falls they were using water power, and had a good many Swan lamps running very satisfactorily from their Brush arc circuits. These incandescent lights were used in connection with a Brush box, both 38 and 92 volts. Some of them were located several miles away from the station, some of them over in Canada. They crossed the river twice with their wires, but not under water. "We do not use barrels for the protection of our wires either, but they cross on one bridge and come back on the other. One of our circuits is 12 miles long. We find no difficulty whatever in using these lamps at that distance from the dynamo. But I have come to learn more about wiring. Our wiring has been done by men who have grown up in the business with us, and the only lessons they have had have been lessons of experience." In reply to questions, Mr. Rhodes continued:—"We are running in the usual way, seven 38 or sixteen 92 volt lamps from these distributing boxes. I am sorry to say we have not had any way yet of keeping a record of the life of the lamps thus run in hours. We run our lamps either for all-night business or for half-night business, and those who run for part of the night are permitted to burn their lamps until 10 o'clock in some cases; those lamps burn all the way up till 10, 11, 12, and 1 o'clock. With a number of boxes, I suppose the average burning will be from one hour before sunset until 10 or 11 o'clock at night. We keep account of our breakage, not by hours but by the month. We find that for the last three months our breakage has been three lamps per month to each set of seven. For some reason or other not quite clear to us, the breakage is becoming less and less. Whether the manufacturers are making the lamps better, or whether we are learning to run the dynamo more steadily, and to keep our current more regular, I am not prepared to say; but certainly we are gaining in that respect. Thus the breakage will now be about two per month to each set of seven, which would be twenty-four in a year. Any one can figure out the expense of that, and will find that it is not a remarkably serious item of expense, as this is practically almost the entire expense of running. How this would be varied by running by steam I am not prepared to say, but I believe that as we run by water-power our current is much more regular than it can be made by the best steam engines; and, I believe, that in that respect we have an advantage over steam engines. Another point is, our expense is so very little on other items that we consider this breakage to be our principal item of expense. Our entire cost for horse-power is $15 per horse-power per year, including the rent of the building and the installation of the wheel. We do not own the wheel, but rent power. As the power required for seven 38-volt lamps is considerably less than a horse-power, the power expense is very small indeed. The expense also of the men who take care of these lamps is very small indeed, because it is delegated to the lamp trimmers and occupies very little of their time. The success with us is so great that it is at least satisfactory. The lights are satisfactory to our customers, and the prices are as satisfactory to us as to them." The 16 candle-power lights easily take the place of a 5ft. gas burner. They are run on the same circuit as the arc lamps; but we have been advised that if we put our entire number of incandescent lamps in groups, on a circuit by themselves, the breakage will be still less. But we cannot do that without doubly covering our entire district, and we prefer to continue doing as we are, with a single system of wiring covering our entire territory, sandwiching in among our arcs the incandescents, just as they happen to come.

Mr. DE CAMP inquired as to price compared with that obtained for the arc lamp displaced by the group.

Mr. RHODES: We charge in all cases $1 per month for each incandescent lamp. We get $7 for each set of seven. Where we put in the sixteen we make $1 reduction, leaving the charge $15 for the sixteen lamps, a slight inducement to the customer to take the additional number. We add 50 per cent. to that for lamps that burn all night. For arc lights we receive $8 per month single lamps, and $10 double lamps. In some cases we find that we have been obliged to substitute the incandescent lamps for the arc, whether we wanted to do it or not, and I believe that has been found to be the experience of others, as already stated. There is a call for incandescent lamps, no matter how well the arcs burn—and ours burn as well as anybody's. Nearly all the customers who occupy small stores, as is the case in small towns, and to a great extent in large towns, prefer the incandescent lamps to the best possible arc lamp in existence. We find that there is a call for these incandescent lamps from those who have been using arc lamps. We find that there is not a very great difference between the profit of one and the other, and we try to balance one against the other at those prices which I have named. We are very much pleased to substitute the incandescent lamps for the arc. We try to fix our prices so that it will be as satisfactory to ourselves in one case as in the other, and then we let the customer make his own selection.

(To be continued.)

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PHOSPHOR-BRONZE *VERSUS* IRON WIRE.

At a recent meeting of the Société Belge des Electriciens, M. Bède, having enumerated the well-known advantages of phosphor-bronze for telegraphic and telephonic purposes, inquired why it was that the material had not been more widely employed in Belgium, especially in view of the fact of the introduction of the Van Rysselberghe system, for which a non-magnetic line was very desirable. In replying to these questions at a subsequent meeting, M. Banneux stated that the question of employing either bronze or copper wires for telegraphic purposes occupied the attention of the Belgian Government as long ago as the summer of 1883. In the course of this and the following year 440 kilometres of bronze and 150 kilometres of hard drawn copper were erected. The advantages of these wires when working with currents of brief duration and the increased conductibility and high tensile strength were fully recognised, but the question came to be one of cost. In the first place, the lifetime of an iron wire 4mm. diameter is known to extend over an average period of at least 25 years; but the life-time of the non-magnetic wires is still an unknown quantity. While this is the case it is impossible to arrive at any definite conclusion as to the relative cost of the two materials. At the same time the cost of a phosphor-bronze wire of 1·4mm. is 50 per cent. higher than that of an iron wire of 4mm., which represents the same conductivity. A phosphor-bronze wire of the most recent manufacture will have a conductivity equal to 33 per cent. of that of pure copper, with a tenacity of about 48 tons per square inch. Whenever it becomes a question of erecting an entirely new line of posts, whether for telegraphic or for telephonic purposes, there can be no hesitation in adopting either bronze or copper wires, for then the additional cost of the lines is fully balanced by the diminution in the number of posts required, and the saving not only of material but in the cost of transport and of labour. In the meantime, taking into consideration the difference in the cost, the superiority of the bronze wire was not of so overwhelming a character as to justify the entire replacement of the iron wires at present in use. It may be added that hard drawn copper wire is now obtainable having a tensile strength of 19 tons to the square inch, and owing to the great depreciation in the value of this metal its price compares favourably with iron wire of the same conductivity. The specific resistance is usually about 96 per cent. of that of pure copper.

CHEMISTRY AS A SCIENCE.

(Continued from page 416.)

But if the evidence in favour of Prout's hypothesis in its original guise is deemed insufficient, may not Mr. Clarke's suggestion of half multiples place it upon an entirely new basis? Suppose that the unit of the scale, the body whose atomic weight, if multiplied by a series of whole numbers, gives the atomic weights of the remaining elements, is not hydrogen, but some element of still lower atomic weight? We are here at once reminded of helium—an element purely hypothetical as far as our earth is concerned, but supposed by many authorities, on the faith of spectroscopic observations, to exist in the sun and in other stellar bodies. Most solar eruptions present merely the characteristic lines of hydrogen, C, F, and H, and along with them one particular line which at first was classed in the sodium group, but which is a little more refrangible, and is designated by the symbol D_3. According to Mr. Norman Lockyer and the late Father Secchi, this ray undergoes modifications not comparable to those affecting other rays of the chromosphere. In the corresponding region of the spectrum no dark ray has been observed. That the accompanying lines, C, F, and H, pertain to hydrogen is evident; and as D_3 has never been obtained in any other spectrum, it is supposed to belong to a body foreign to our Earth, though existing in abundance in the chromosphere of the sun. To this hypothetical body the name helium is assigned.

In an able memoir on this subject, read before the Academy of Brussels, the Abbé E. Spée shows that, if helium exists, it enjoys two very remarkable properties. Its spectrum consists of a single ray, and its vapour possesses no absorbent power. The simple single ray, though I believe unexampled, is by no means an impossible phenomenon, and indicates a remarkable simplicity of molecular constitution. The non-absorbent property of its vapour seems to be a serious objection to a general physical law. Professor Tyndall has demonstrated that the absorptive power increases with the complexity of molecular structure, and hence he draws the conclusion that the simpler the molecule the feebler the absorption. This conclusion the Abbé Spée regards as perfectly legitimate; but it neither explains nor even necessitates the absence of *all* absorptive power.

Granting that helium exists, all analogy points to its atomic weight being below that of hydrogen. Here, then, we may have the very element, with atomic weight half that of hydrogen, required by Mr. Clarke as the basis of Prout's law.

But a more important piece of evidence for the compound nature of the chemical elements has yet to be considered. Many chemists must have been struck with certain peculiarities in the occurrence of the elements in the Earth's crust; it is a stale remark that we do not find them evenly distributed throughout the globe. Nor are they associated in accordance with their specific gravities; the lighter elements placed on or near the surface, and the heavier ones following serially deeper and deeper. Neither can we trace any distinct relation between local climate and mineral distribution. And by no means can we say that elements are always or chiefly associated in nature in the order of their so-called chemical affinities; those which have a strong tendency to form with each other definite chemical combinations being found together, whilst those which have little or no such tendency exist apart. We certainly find calcium as carbonate and sulphate, sodium as chloride, silver and lead as sulphides; but why do we find certain groups of elements with little affinity for each other yet existing in juxtaposition or commixture? The members of some of these groups are far from plentiful, not generally or widely diffused, and certainly they are not easy to separate.

As instances of such grouping we may mention—

1. Nickel and cobalt, of which it may be said that had their compounds been colourless they would have been long regarded as identical, and possibly even yet would not have been separated.

2. The two groups of platinum metals.

3. The so-called "rare earths," occurring in gadolinite, samarskite, &c., and evidently becoming more numerous the more closely they are examined.

Certain questions here suggest themselves:—Is the series of these elements like a staircase or like an inclined plane? Will they the more closely they are scrutinised, be found to fade away the more gradually the one into the other? Further, will a mixture hitherto held to be simple, like (*e.g.*) didymium, be capable of being split up in one direction only, or in several? I have been led to ask this last question because I have separated from didymium bodies which seem to agree neither with the praseodymium and neodymium of Dr. Auer von Welsbach, nor with the components detected by M. de Boisbaudran and M. Demarçay.

Why, then, are these respective elements so closely associated? What agency has brought them together?

An eminent physicist evades the difficulty by suggesting that their joint occurrence is simply an instance of the working of the familiar principle "Birds of a feather flock together." In their chemical and physical attributes these rare earths are so closely similar that they may be regarded as substantially identical in all the circumstances of solution and precipitation to which they may have been exposed during geological ages.

But do we, in point of fact, recognise any such agency at work in nature? Is there any power which regularly and systematically sorts out the different kinds of matter from promiscuous heaps, conveying like to like and separating unlike from unlike? I must confess that I fail to trace any such distributive agency, nor, indeed, do I feel able to form any distinct conception of its nature.

I must here remark that coral worms in some cases do effect a separation of certain kinds of matter. Thus a *Gorgonia* of the species *Melithœa*, and *Mussa sinuosa*, undoubtedly eliminate from sea-water not merely lime, but even yttria; and other recent corals, *Pocillopora damicornis*, and a *Symphyllia* close to the yttria-secreting *Mussa*, separate samaria from sea-water. Sea-weeds and aquatic mollusks contain a larger proportion of iodine and bromine than the waters which they inhabit, and may thus be said to separate out these elements from the chlorine with which they are mingled.

But if we examine these cases of elimination we see that they are limited in their scope. They extend only to substances existing in solution, of which there is a fresh supply always at hand, and which are capable of entering into the animal or vegetable economy. Again, the elimination of iodine and bromine, effected as just described, is of a very imperfect character, and when such water plants and animals die and decay, their constituents will be again distributed in the water.

We cannot well consider that nickel and cobalt have been deposited in admixture by organic agency, nor yet the groups iridium, osmium, and platinum—ruthenium, rhodium, and palladium.

Since the earthy metals to which I have referred—such as yttrium, samarium, holmium, erbium, thulium, ytterbium, &c.—are very rare, the probability of their ever having been brought together in some few uncommon minerals discovered only in a few localities must be regarded as trifling indeed, if we suppose that these metals had at any time been widely diffused in a state of great dilution with other matter. The features which we have just recognised in these earths seem to point to their formation severally from some common material placed in conditions in each case nearly identical. The case is strengthened by a consideration of the other groups of elements, also similar in properties, having little affinity for each other and occurring in admixture; either all or at least some of the elements concerned being, moreover, decidedly rare. Thus, we have nickel and cobalt not plentiful or widely distributed; cobalt, perhaps, never found absolutely free from nickel, and *vice versâ*. We have also the two platinum groups, where very similar features prevail.

A weighty argument in favour of the compound nature of the elements is that drawn from a consideration of the compound radicals, or, as they might be called, pseudo elements. Their similarity with the accepted elements is perfectly familiar to all chemists. If, for example, we suppose that in some age or in some country men of science were cognisant of the existence and of the behaviour of cyanogen, but had not succeeded in resolving it into its constituents, nothing, surely, would prevent their

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viewing it as an element, and assigning it a place with the halogens. It may fairly be held that if a body which we know to be compound can be found playing the part of an element, this fact lends a certain plausibility to the supposition that the elements also are not absolutely simple. This line of thought, or at least one closely approximating to it, was worked out by Dr. Carnelley in a paper read before this Association at its last meeting. From a comparison of the physical properties of inorganic with those of organic compounds, Dr. Carnelley concludes that "*the elements, as a whole, are analogous to the hydrocarbon radicles.*" This conclusion, if true, he adds, should lead to the further inference that the so-called elements are not truly elementary, being made up of at least two absolute elements, named provisionally A and B. Hence, he argues, it should be possible to build up a series of compounds of these two primary elements which would correspond to what we now call elements. Such an arrangement, to be admissible, would have to fulfil certain conditions:—The secondary elements thus generated from A and B must exhibit the phenomena of periodicity, and the series would have to form octaves; the entire system is bound to display some feature corresponding to the "odd and even series" of Mendeleeff's classification; the atomic weights must increase across the system from the first to the seventh group: that is, from the positive to the negative end of each series; the atomicity would have to increase from the first to the middle group, and then either increase or decrease to the seventh group; some feature should appear corresponding to the eighth group; and, lastly, the atomic weights in such a system ought to agree with the atomic weights as experimentally determined.

This last condition Dr. Carnelley rightly regards as the most crucial, and he finds his arrangement gives atomic weights which in a majority of instances coincide approximately with the actual atomic weights. Thus out of a total of sixty-one elements whose atomic weights have been determined with at least approximate accuracy, and whose places in the periodic system are not disputed, twenty-seven agree almost exactly with the actual numbers, whilst 19 others are not more than one unit astray.

For a detailed consideration of the conclusions which follow from Dr. Carnelley's views I must refer to his paper as read at our last meeting. Two points bear more especially upon the subject now under consideration—that is, if this speculation on the genesis of the elements is well founded. First, the existence of elements of identical atomic weights, isomeric with each other, would be possible; as such Dr. Carnelley mentions respectively nickel and cobalt (now found to have slightly different atomic weights), rhodium and ruthenium, osmium and iridium, and the metals of some of the rare earths. Secondly, in Dr. Carnelley's scheme all the chemical elements save hydrogen are supposed to be composed of two simpler elements, A = 12 and B = −2. Of these he regards A as a tetrad identical with carbon, and B as a monad of negative weight—perhaps the ethereal fluid of space.

Dr. Carnelley's three primary elements, therefore, are carbon, hydrogen, and the ether.

Starting from the supposition that pristine matter was once in an intensely heated condition, and that it has reached its present state by a process of free cooling, Dr. E. J. Mills suggests that the elements as we now have them are the result of successive polymerisations. Dr. Mills reminds us that chemical substances in the process of cooling naturally increase in density, and, if such increase be measured as a function of time or of temperature, we sometimes observe that there are critical points corresponding to the formation of new and well-defined substances. In this manner ordinary phosphorus is converted into the red variety, I is transformed into I_2, S_2 becomes S_6, and NO_2 N_2O_4. Among organic bodies styrol, in like manner, according to Dr. Mills, is converted into metastyrol, aldehyd into paraldehyd, the cynates into cyanurates, and turpentine into metaterebenthene. At the critical points above referred to heat is liberated in especial abundance, and the bodies thus formed are known as polymers. If we could gradually cool down substances through a vast range of temperature, we should then probably discover a much greater number of such critical points, or points of multiple proportion, than we have been able to discover experimentally.

The heat given out in the act of polymerisation naturally reverses to some extent the polymerisation itself, and so causes a partial return to the previous condition of things. This forward and backward movement, several times repeated, constitutes "periodicity." Dr. Mills regards variable stars as instances, now in evidence, of the genesis of elementary bodies.

From a study of the classification of the elements, Dr. Mills is of opinion that the only known polymers of the primitive matter are arsenic, antimony, and perhaps erbium and osmium; whilst zirconium, ruthenium, samarium, and platinum approximate to the positions of other polymers. Hence, from this genetic view, these elements may be described as products of successive polymerisations.

I must now call attention to a method of illustrating the periodic law, proposed by my friend Prof. Emerson Reynolds, of the University of Dublin, which will here assist us. Prof. Reynolds points out that in each period the general properties of the elements vary from one to another with approximate regularity until we reach the seventh member, which is in more or less striking contrast with the first element of the same period, as well as with the first of the next. Thus chlorine, the seventh member of Mendeleeff's third period, contrasts sharply both with sodium, the first member of the same series, and with potassium, the first member of the next series; whilst, on the other hand, sodium and potassium are closely analogous. The six elements whose atomic weights intervene between sodium and potassium vary in properties, step by step, until chlorine, the contrast to sodium, is reached. But from chlorine to potassium, the analogue of sodium, there is a change in properties *per saltum*. Further, such alternations of gradual and abrupt transitions are observed as the atomic weights increase. If we thus recognise a contrast in properties—more or less decided—between the first and the last members of each series, we can scarcely help admitting the existence of a point of mean variation within each system. In general, the *fourth* element of each series possesses the properties we might expect a transition-element to exhibit. If we examine a particular period—for instance, that one whose meso-element is silicon, we note:—*First*, that the three elements of lower atomic weight than silicon, viz., sodium, magnesium, and aluminium, are distinctly *electro-positive* in character, while those of higher atomic weight, viz., phosphorus, sulphur, and chlorine, are as distinctly *electro-negative*. Throughout the best known periods this remarkable subdivision is observable, although, as might be anticipated, the differences become less strongly marked as the atomic weights increase. *Secondly*, that the members above and below the meso-element fall into pairs of elements which, while exhibiting certain analogies, are generally in more or less direct chemical contrast. Thus, in the silicon period we have—

	Si^{iv}	
	+ Al$'''$	P$'''$ −
	+ Mg$''$	S$''$ −
	+ Na$'$	Cl$'$ −

This division also happens, in many cases, to coincide with some characteristic valence of the contrasted elements. It is noteworthy, however, that the members on the electro-negative side exhibit the most marked tendency to variation in atom-fixing power, so that valence alone is an untrustworthy guide to the probable position of an element in a period.

Thus, for the purpose of graphic translation Prof. Reynolds considers that the fourth member of a period—silicon, for example—may be placed at the apex of a symmetrical curve, which shall represent, for that particular period, the direction in which the properties of the series of elements vary with rising atomic weights.

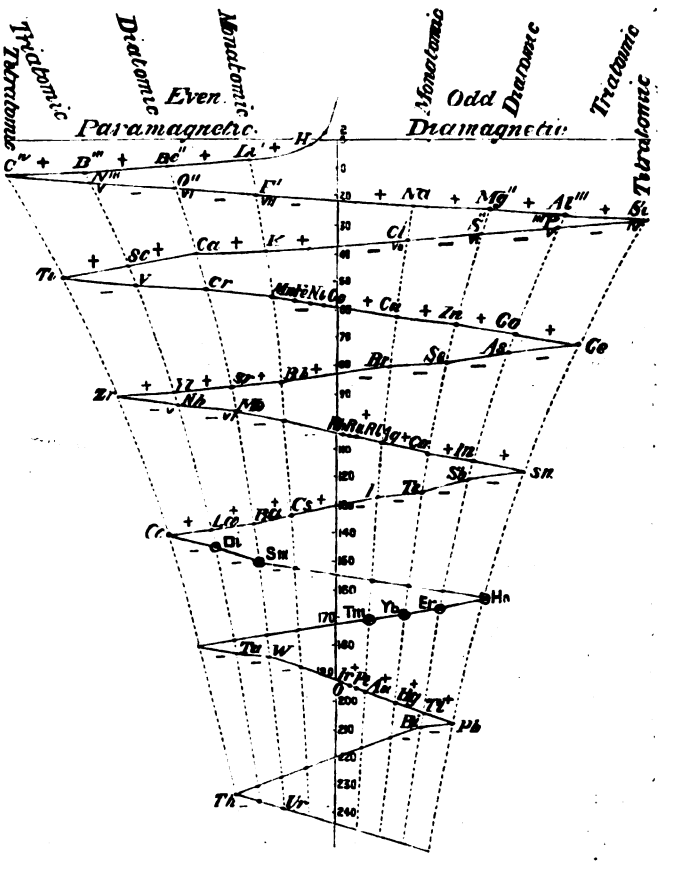

FIG. 1.

In the drawing before you (Fig. 1) I have modified Prof. Reynolds's diagram in one or two points. I have turned it the reverse way, as it is more convenient to start from the top and proceed downwards. I have represented the pendulous swing as gradually declining in amplitude according to a mathematical law, and I have introduced another half-swing of the pendulum between cerium and lead, which not only renders the oscillations more symmetrical, but brings gold, mercury, thallium, lead, and bismuth on the side where they are in complete harmony with members of foregoings groups, instead of being out of harmony with them. This modification has another advantage, inasmuch as it leaves many gaps to be hereafter filled in with new elements just when the development of research is beginning to demand room for such expansion.

I do not, however, wish to infer that the gaps in Mendeleeff's table, and in this graphic representation of it, necessarily mean that there are elements actually existing to fill up the gaps; these gaps may only mean that at the birth of the elements there was an easy potentiality of the formation of an element which would fit into the place.

Following the curve from hydrogen downwards we find that the elements forming Mendeleeff's eighth group are to be found near three of

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the ten nodal points. These bodies are "interperiodic," both because their atomic weights exclude them from the small periods into which the other elements fall, and because their chemical relations with certain members of the adjacent periods show that they are probably interperiodic in the sense of being transitional.

This eighth group is divided into the three triplets—iron, nickel, and cobalt; rhodium, ruthenium, and palladium; iridium, osmium, and platinum. The members of each triplet have often been regarded as modifications of one single form of matter.

Notice how accurately the series of like bodies fit into this scheme. Beginning at the top, run the eye down analogous positions in each oscillation, taking either the electro-positive or electro-negative swings:—

N	Be	Li	Na	Mg	Al	Si	P	S	Cl	C
V	Ca	K	Cu	Zn	Ga	Ge	As	Se	Br	Ti
Nb	Sr	Rb	Ag	Cd	In	Sn	Sb	Te	I	Zr
—	Ba	Cs	—	—	—	—	—	—	—	—
Ta			Au	Hg	Tl	Pb	Bi			

Notice, also, how orderly the metals discovered by spectrum analysis fit in their places—gallium, indium, and thallium.

The symmetry of nearly all this series proclaims at once that we are working in the right direction. We can also learn much from the anomalies here visible. Look at the places marked with a circle; didymium, samarium, holmium, erbium, ytterbium, and thulium. Didymium cannot follow in order after the triad nitrogen, vanadium, columbium; nor erbium follow phosphorus, arsenic, antimony; nor thulium follow chlorine, bromine, iodine; nor ytterbium follow potassium, rubidium, cæsium. The inference to be drawn is that these bodies are out of place, owing to their atomic weights not having been correctly determined—an inference which is strengthened by the knowledge that the elementary character of some of these bodies is more than doubtful, whilst the chemical attributes of most of them are unknown.

The more I study the arrangement of this zigzag curve the more I am convinced that he who grasps the key will be permitted to unlock some of the deepest mysteries of creation. Let us imagine if it is possible to get a glimpse of a few of the secrets here hidden. Let us picture the very beginnings of time, before geological ages, before the earth was thrown off from the central nucleus of molten fluid, before even the sun himself had consolidated from the original *protyle*.* Let us still imagine that at this primal stage all was in an ultragaseous state, at a temperature inconceivably hotter† than anything now existing in the visible universe; so high, indeed, that the chemical atoms could not yet have been formed, being still far above their dissociation point. In so far as *protyle* is capable of radiating or reflecting light, this vast sea of incandescent mist, to an astronomer in a distant star, might have appeared as a nebula, showing in the spectroscope a few isolated lines, forecasts of hydrogen, carbon, and nitrogen spectra.

But in course of time some process akin to cooling, probably internal, reduces the temperature of the cosmic *protyle* to a point at which the first step in granulation takes place; matter as we know it comes into existence, and atoms are formed. As soon as an atom is formed out of *protyle* it is a store of energy, potential (from its tendency to coalesce with other atoms by gravitation or chemically) and kinetic (from its internal motions). To obtain this energy the neighbouring *protyle* must be refrigerated by it,‡ and thereby the subsequent formation of other atoms will be accelerated. But with atomic matter the various forms of energy which require matter to render them evident begin to act; and amongst others, that form of energy which has for one of its factors what we now call *atomic weight*. Let us assume that the elementary *protyle* contains within itself the potentiality of every possible combining proportion or atomic weight. Let it be granted that the whole of our known elements were not at this epoch simultaneously created. The easiest formed element, the one most nearly allied to the *protyle* in simplicity is first born. Hydrogen—or shall we say helium?—of all the known elements the one of simplest structure and lowest atomic weight, is the first to come into being. For some time hydrogen would be the only form of matter (as we now know it) in existence, and between hydrogen and the next formed element there would be a considerable gap in time, during the latter part of which the element next in order of simplicity would be slowly approaching its birth-point; pending this period we may suppose that the evolutionary process which soon was to determine the birth of a new element would also determine its atomic weight, its affinities, and it chemical position.

In the original genesis the longer the time occupied in that portion of the cooling down during which the hardening of the *protyle* into atoms took place, the more sharply defined would be the resulting elements; and, on the other hand, with more irregularity in the original cooling, we should have a nearer approach to the state of the elemental family such as we know it at present.

In this way it is conceivable that the succession of events which gave us such groups as platinum, osmium, and iridium—palladium, ruthenium, and rhodium—nickel and cobalt, if the operation of genesis had been greatly more prolonged, iron, would have resulted in the birth of only one element of these groups. It is also probable that by a much more rapid rate of cooling, elements would originate even more closely related than are nickel and cobalt, and thus we should have formed the nearly allied elements of the serium, yttrium, and similar groups; in fact the minerals of the class of samarskite and gadolinite may be regarded as the cosmical lumber-room where the elements in a state of arrested development—the unconnected missing links of inorganic Darwinism—are finally aggregated.

(To be continued.)

* We require a word, analogous to protoplasm, to express the idea of the original primal matter existing before the evolution of the chemical elements. The word I have ventured to use for this purpose is compounded of πρό (*earlier than*) and ὕλη (*the stuff of which things are made*. The word is scarcely a new coinage, for 600 years ago Roger Bacon wrote in his *De Arte Chymiæ*, "The elements are made out of ὕλη, and every element is converted into the nature of another element."

† I am constrained to use the words expressive of high temperature; but I confess I am unable clearly to associate with *protyle* the idea of hot or cold. *Temperature*, *radiation*, and *free cooling* seem to require the periodic motions that take place in the chemical atoms; and the introduction of centres of periodic motion into protyle would constitute its being so far changed into chemical atoms.

‡ I am indebted to my friend G. Johnstone Stoney, F.R.S., for the idea here put forward, as well as for other valuable suggestions and criticisms on some of the theoretical questions here treated of.

THE BRITISH ASSOCIATION MEETING.

PRESIDENTIAL ADDRESS.

(Concluded from page 417.)

I have elsewhere endeavoured to show, on the evidence found in Canada, that the occurrence of marine shells, land plants, and insects in the glacial deposits of that country indicates not so much the effect of general interglacial periods as the local existence of conditions like those of Grinnelland and Greenland, in proximity to each other at one and the same period, and depending on the relative levels of land and the distribution of ocean currents and ice-drift.*

I am old enough to remember the sensation caused by the delightful revelations of Edward Forbes respecting the zones of animal life in the sea, and the vast insight which they gave into the significance of the work on minute organisms previously done by Ehrenberg, Lonsdale, and Williamson, and into the meaning of fossil remains. A little later the soundings for the Atlantic cable revealed the chalky foraminiferal ooze of the abyssal ocean; still more recently the wealth of facts disclosed by the "Challenger" voyage, which naturalists have not yet had time to digest, have opened up to us new worlds of deep sea life.

The bed of the deep Atlantic is covered for the most part by a mud or ooze largely made up of the *débris* of foraminifera and other minute organisms mixed with fine clay. In the North Atlantic the Norwegian naturalists call this the Biloculina mud. Further south the "Challenger" naturalists speak of it as Globigerina ooze. In point of fact it contains different species of foraminiferal shells, Globigerina and Orbulina being in some localities dominant, and in others other species, and these changes are more apparent in the shallower portions of the ocean.

It is also to be observed that there are means for disseminating coarse material over the ocean-bed. There are in the line of the Arctic current on the American coast great sand-banks, and off the coast of Norway sand constitutes a considerable part of the bottom material. Soundings and dredgings off Great Britain, and also off the American coast, have shown that fragments of stone referable to Arctic lands are abundantly strewn over the bottom along certain lines, and the Antarctic continent, otherwise almost unknown, makes its presence felt to the dredge by the abundant masses of crystalline rock drifted far from it to the north. These are not altogether new discoveries. I had inferred many years ago, from stones taken up by the hooks of fishermen on the banks of Newfoundland, that rocky material from the north is dropped on these banks by the heavy ice which drifts over them every spring, that these stones are glaciated, and that after they fall to the bottom sand is drfted over them with sufficient velocity to polish the stones and to erode the shelly coverings of Arctic animals attached to them.† If then the Atlantic basin were upheaved into land we should see beds of sand, gravel, and boulders with clay flats and layers of marl and limestone. According to the "Challenger" Reports, in the Antarctic seas S. of 64deg. there is blue mud with fragments of rock in depths of 1,200 to 2,000 fathoms. The stones, some of them glaciated, were granite, diorite, amphibolite, mica schist, gneiss, and quartzite. This deposit ceases and gives place to Globigerina ooze and red clay at 46deg. to 47deg. S., but even further north there is sometimes as much as 49 per cent. of crystalline sand. In the Labrador current a block of syenite weighing 490lbs. was taken up from 1,340 fathoms, and in the Arctic current 100 miles from land was a stony deposit, some stones being glaciated. Among these were smoky quartz, quartzite, limestone, dolomite, mica schist, and serpentine; also particles of monoclinic and triclinic felspar, hornblende, augite, magnetite, mica, and glauconite, the latter no doubt formed in the sea-bottom, the others drifted from Eozoic and Palæozoic formations to the north.‡

A remarkable fact in this connection is that the great depths of the sea are as impassable to the majority of marine animals as the land itself. According to Murray, while twelve of the "Challenger's" dredgings taken in depths greater than 2,000 fathoms gave 92 species, mostly new to science, a similar number of dredgings in shallower water near the land gave no less than 1,000 species. Hence arises another apparent paradox relating to the distribution of organic beings. While at first sight it might seem that the chances of wide distribution are exceptionally great for marine species, this is not so. Except in the case of those which enjoy a period of free locomotion when young, or are floating and pelagic, the deep ocean sets bounds to their migrations. On the other hand the spores of crytogamic plants may be carried for vast distances by the wind, and the growth of volcanic islands may effect connections which, though only temporary, may afford opportunity for land animals and plants to pass over.

With reference to the transmission of living beings across the Atlantic,

* "Notes on Post-Pliocene of Canada," 1872. One well-marked interval only has been established in the glacial deposits of Canada.

† "Notes on Post-Pliocene of Canada," 1872.

‡ General Report, "Challenger" Expedition

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we have before us the remarkable fact that from the Cambrian age onwards there were on the two sides of the ocean many species of invertebrate animals which were either identical or so closely allied as to be possibly varietal forms.* In like manner the early plants of the Upper Silurian, Devonian, and Carboniferous present many identical species; but this identity becomes less marked in the vegetation of the more modern times.

In so far as plants are concerned, it is to be observed that the early forests were largely composed of cryptogamous plants, and the spores of these in modern times have proved capable of transmission for great distances. In considering this we cannot fail to conclude that the union of simple cryptogamous fructification with arboreal stems of high complexity, so well illustrated by Dr. Williamson, had a direct relation to the necessity for a rapid and wide distribution of these ancient trees. It seems also certain that some spores, as, for example, those of the Rhizocarps,† a type of vegetation abundant in the Palæozoic, and certain kinds of seeds, as those named *Ethcotesta* and *Pachytheca*, were fitted for flotation. Farther, the periods of Arctic warmth permitted the passage around the northern belt of many temperate species of plants, just as now happens with the Arctic flora; and when these were dispersed by colder periods they marched southward along both sides of the sea on the mountain chains.

The same remark applies to northern forms of marine invertebrates, which are much more widely distributed in longitude than those further south. The late Mr. Gwyn Jeffreys, in one of his latest communications to this Association, stated that 54 per cent. of the shallow water mollusks of New England and Canada are also European, and of the deep sea forms 30 out of 35, these last of course enjoying greater facilities for migration than those which have to travel slowly along the shallows of the coasts in order to cross the ocean and settle themselves on both sides. Many of these animals, like the common mussel and sand clam, are old settlers which came over in the Pleistocene period, or even earlier. Others, like the common periwinkle, seem to have been slowly extending themselves in modern times, perhaps even by the agency of man. The older immigrants may possibly have taken advantage of lines of coast now submerged, or of warm periods, when they could creep around by the Arctic shores. Mr. Herbert Carpenter and other naturalists employed on the "Challenger" collections have made similar statements respecting other marine invertebrates, as, for instance, the Echinoderms, of which the deep-sea crinoids present many common species, and my own collections prove that many of the shallow-water forms are common. Dall and Whiteaves‡ have shown that some mollusks and Echinoderms are common even to the Atlantic and Pacific coasts of North America; a remarkable fact, testifying at once to the fixity of these species and to the manner in which they have been able to take advantage of geographical changes. Some of the species of whelks common to the Gulf of St. Lawrence and the Pacific are animals which have no special locomotive powers even when young, but they are northern forms not proceeding far south, so that they may have passed through the Arctic seas. In this connection it is well to remark that many species of animals have powers of locomotion in youth which they lose when adult, and that others may have special means of transit. I once found at Gaspé a specimen of the Pacific species of Coronula, or whale-barnacle, the *C. reginæ* of Darwin, attached to a whale taken in the Gulf of St. Lawrence, and which had probably succeeded in making that passage around the north of America which so many navigators have essayed in vain.

It is to be remarked here that while many plants and marine invertebrates are common to the two sides of the Atlantic, it is different with land animals, and especially vertebrates. I do not know that any fossil insects or land snails or millipedes of Europe and America are specifically identical, and of the numerous species of batrachians of the Carboniferous and reptiles of the Mesozoic all seem to be distinct on the two sides. The same appears to be the case with the Tertiary mammals, until in the later stages of that great period we find such genera as the horse, the camel, and the elephant appearing on the two sides of the Atlantic; but even then the species seem different, except in the case of a few northern forms.

Some of the longer-lived mollusks of the Atlantic furnish suggestions which remarkably illustrate the biological aspect of these questions. Our familiar friend, the oyster, is one of these. The first known oysters appear in the Carboniferous in Belgium and in the United States of America. In the Carboniferous and Permian they are few and small, and they do not culminate till the Cretaceous, in which there are no less than ninety-one so-called species in America alone; but some of the largest known species are found in the Eocene. The oyster, though an inhabitant of shallow water, and very limitedly locomotive when young, has survived all the changes since the Carboniferous age, and has spread itself over the whole northern hemisphere.§

I have collected fossil oysters in the Cretaceous clays of the coulées of Western Canada, in the Lias shales of England, in the Eocene and Cretaceous beds of the Alps, of Egypt, of the Red Sea Coast, of Judea, and the heights of Lebanon. Everywhere and in all formations they present forms which are so variable and yet so similar that one might suppose all the so-called species to be mere varieties. Did the oyster originate separately on the two sides of the Atlantic, or did it cross over so promptly that its appearance seems to be identical on the two sides? Are all the oysters of a common ancestry, or did the causes, whatever they were, which introduced the oyster in the Carboniferous act over again at later periods? Who can tell? This is one of the cases where causation and development—the two scientific factors which constitute the basis of what is vaguely called evolution—cannot easily be isolated. I would recommend to those biologists who discuss these questions to addict themselves to the oyster. This familiar mollusk has successfully pursued its course and has overcome all its enemies, from the flat-toothed selachians of the carboniferous to the oyster-dredgers of the present day, has varied almost indefinitely, and yet has continued to be an oyster, unless indeed it may at certain portions of its career have temporarily assumed the disguise of a Gryphæa or an Exogyra. The history of such an animal deserves to be traced with care, and much curious information respecting it will be found in the report which I have cited.

But in these respects the oyster is merely an example of many forms. Similar considerations apply to all those Pliocene and Pleistocene mollusks which are found in the raised sea-bottoms of Norway and Scotland, on the top of Moel Tryfaen in Wales, and at similar great heights on the hills of America, many of which can be traced back to early Tertiary times, and can be found to have extended themselves over all the seas of the northern hemisphere. They apply in like manner to the ferns, the conifers, and the angiosperms, many of which we can now follow without even specific change to the Eocene and Cretaceous. They all show that the forms of living things are more stable than the lands and seas in which they live. If we were to adopt some of the modern ideas of evolution we might cut the Gordian knot by supposing that, as like causes can produce like effects, these types of life have originated more than once in geological time, and need not be genetically connected with each other. But while evolutionists repudiate such an application of their doctrine, however natural and rational, it would seem that nature still more strongly repudiates it, and will not allow us to assume more than one origin for one species. Thus the great question of geographical distribution remains in all its force, and, by still another of our geological paradoxes, mountains become ephemeral things in comparison with the delicate herbage which covers them, and seas are in their present extent but of yesterday when compared with the minute and feeble organisms that creep on their sands or swim in their waters.

The question remains, Has the Atlantic achieved its destiny and finished its course, or are there other changes in store for it in the future? The earth's crust is now thicker and stronger than ever before, and its great ribs of crushed and folded rock are more firm and rigid than in any previous period. The stupendous volcanic phenomena manifested in Mesozoic and early Tertiary times along the borders of the Atlantic have apparently died out. These facts are in so far guarantees of permanence. On the other hand, it is known that movements of elevation along with local depression are in progress in the Arctic regions, and a great weight of new sediment is being deposited along the borders of the Atlantic, especially on its western side, and this is not improbably connected with the earthquake shocks and slight movements of depression which have occurred in North America. It is possible that these slow and secular movements may go on uninterruptedly until considerable changes are produced; but it is quite as likely that they may be retarded or reversed.

It is possible, on the other hand, that after the long period of quiescence which has elapsed there may be a new settlement of the ocean-bed, accompanied with foldings of the crust, especially on the western side of the Atlantic, and possibly with renewed volcanic activity on its eastern margin. In either case a long time relatively to our limited human chronology may intervene before the occurrence of any marked change. On the whole the experience of the past would lead us to expect movements and eruptive discharges in the Pacific rather than in the Atlantic area. It is therefore not unlikely that the Atlantic may remain undisturbed, unless secondarily and indirectly, until after the Pacific area shall have attained to a greater degree of quiescence than at present. But this subject is one too much involved in uncertainty to warrant us in following it farther.

In the meantime the Atlantic is to us a practically permanent ocean, varying only in its tides, its currents, and its winds, which science has already reduced to definite laws, so that we can use if we cannot regulate them. It is ours to take advantage of this precious time of quietude, and to extend the blessings of science and of our Christian civilisation from shore to shore until there shall be no more sea, not in the sense of that final drying-up of old ocean to which some physicists look forward, but in the higher sense of its ceasing to be the emblem of unrest and disturbance, and the cause of isolation.

I must now close this address with a short statement of the general objects which I have had in view in directing your attention to the geological development of the Atlantic. We cannot, I think, consider the topics to which I have referred without perceiving that the history of ocean and continent is an example of progressive design, quite as much as that of living beings. Nor can we fail to see that, while in some important directions we have penetrated the great secret of Nature, in reference to the general plan and structure of the earth and its waters, and the changes through which they have passed, we have still very much to learn, and perhaps quite as much to unlearn, and that the future holds out to us and to our successors higher, grander, and clearer conceptions than those to which we have yet attained. The vastness and the might of ocean and the manner in which it cherishes the feeblest and most fragile beings, alike speak to us of Him who holds it in the hollow of His hand, and gave to it of old its boundaries and its laws; but its teaching ascends to a higher tone when we consider its origin and history, and the manner in which it has been made to build up continents and mountain chains, and at the same time to nourish and sustain the teaming life of sea and land.

* See Davidson's "Monographs on Brachiopods;" Etheridge "Address to Geological Society of London;" Woodward "Address to Geologists' Association;" also Barrande's "Special Memoirs on the Brachiopods, Cephalopods, &c.;" and Hall, "Palæontology of New York;" Billings, "Reports on Canadian Fossils;" and Matthews, "Cambrian of New Brunswick," *Trans.* R.S.C.

† See paper by the Author on Palæozic Rhizocarps, *Chicago Trans.*, 1886.

‡ Dall, *Report on Alaska;* Whiteaves, *Trans.* R.S.C.

§ White, *Report U.S. Geol. Survey*, 1882-83.

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COMPANIES' MEETINGS.

Direct Spanish Telegraph Company (Limited).

The twenty-sixth ordinary general meeting of this Company was held at Winchester House, Old Broad-street, on Thursday, under the presidency of Sir James Anderson.

The MANAGER (Mr. C. Gerhardi) read the notice calling the meeting.

The CHAIRMAN then said: I have very little to say, and I need say as little as possible, as we have far more important business to go to. At the last meeting I held out to the shareholders the necessity of lifting our cable, and seeing what could be done with it, and whether we should have to abandon it altogether. We have picked it up, and it is now being overhauled, with a view of getting for it what we can. It is not very easy to sell an old cable, but I do not think it will cost the Company anything, at all events for picking it up. You already know that it was too bad to repair or to make anything like a good cable of it for relaying. The only other remarks I have to make as to our ordinary report is that our expenditure is £189 less than last year, and after three months' trial with the reduced tariff we are only £56 worse than before, compared with any other three months. I will make no other remark on this report at present, but will forthwith move, "That the report and accounts now presented be received and adopted."

Mr. EDMUND ETLINGER seconded the motion.

Mr. A. BAKER asked the cost of picking up the cable, and by whom it was done.

The CHAIRMAN said that the work was done by the Eastern Telegraph Company at cost price, and the cost would be nearly £7,000.

Mr. BAKER said it was not shown in the report.

The CHAIRMAN replied that it was not all in this half year's accounts, and that it would have to come before the shareholders again. They had not yet been offered anything like the amount he had stated for it; but he was trying to bring about an arrangement by which they would receive more. In further reply to Mr. C. H. Cochrane, the Chairman said the original cost of the Bilbao cable, including its removal to Santander and re-establishing it at Bilbao, was £126,000, with stores and other things. It would be remembered that this amount was paid when cables were dearer, when concessions cost something, and promoters required to be paid also.

Mr. BAKER said that the capital of the 10 per cent. preference shareholders was raised exclusively for the Marseilles-Barcelona cable, irrespective of the first venture from England to Spain.

The CHAIRMAN replied that it was for effecting this purchase and "other purposes" of the Company. He then read the resolution passed referring to the issue of the preference shares.

Mr. COCHRANE inquired whether he understood from the Chairman that the whole of the old cable had been picked up.

The CHAIRMAN: No, all that could be picked up—about 150 miles.

Mr. COCHRANE: The cable for which that money appears in our accounts is lost.

The CHAIRMAN: Entirely lost.

Mr. BANNATYNE said he objected to the following passage in the report "They" (meaning the Directors), "enclose a special report on the financial steps which are requisite to be taken in consequence of the loss of this cable as an asset." He did not agree with that paragraph because, in his opinion, the proposals were not requisite, and he was prepared at the extraordinary meeting to maintain that view.

The CHAIRMAN said that to meet this objection they would insert the words "they deem" in place of the word "are" in the passage quoted.

Mr. BANNATYNE said that with that alteration he would agree to the motion.

The CHAIRMAN, in answer to Mr. COCHRANE, said that the cost of sending out the proxies was £3, and that if the shareholders objected to pay it the Directors would do so.

The motion, as altered, was then agreed to.

An extraordinary general meeting was afterwards held.

The CHAIRMAN said that he expected the proposal for reducing the capital to be severely criticised, because he himself had been against it very much at starting. He had thought that they might find some plan of inducing the preference shareholders, by giving them a little more than the ordinary shareholders, to accept the proposal more readily, and as the preference shareholders were always nearest a dividend, he thought they ought to be mollified by something of the kind. They had, however, been told, and they found plenty of reasons for seeing its force, that in winding up, for example, if they were compelled to wind up, the ordinary shareholders, who held two-thirds of the whole of the capital, would get two-thirds whatever the result might be in disposing of the property, and the preference shareholders only one-third. Again, the preference shares had only a preference upon the revenue or dividend. They had no preference upon anything else, and it was perfectly obvious to every one that without the votes of the ordinary shareholders they could no more make an adjustment of the capital than they could without the votes of the preference shareholders. Both sides had their rights, and must be reasoned with, and he hoped they would see the matter from the Directors' point of view. If they had given the preference shareholders something more, they had plenty of reasons for knowing that the ordinary shareholders would not have voted and would not vote for the adjustment of the capital. His own notion was that if they could have given the preference shareholders £6, the scheme would have been easier to carry than the present one, and that view he would argue as long as he had a leg to stand upon. There were, however, large and important holders of ordinary shares who said that they would not assent to that, and he understood from their legal adviser, who had taken advice, that they would have infinitely more difficulty in doing anything of that kind than was proposed in the plan before them. After all sorts of considerations and taking advice from all useful sources, they came to the conclusion that there was nothing better to advise the shareholders to accept than the plan submitted by the Directors. There had been an argument advanced by some shareholders in letters to the Directors (they had only had four letters) that if they had reduced the dividend upon the preference shares, and given, for instance, 7 per cent. instead of 10 per cent., the proposal would have been more equitable; but it was illogical, and it would not be so easy to put through the Court. Indeed it was not even legal, and they were advised they could not carry it. But it was an idea which he also had held. The object of the Directors, of course, was that they should be able to ride a living horse instead of whipping a dead one for ten years—that they should make the undertaking a living concern, and if they went on prosperously that would advance their shares in the market, make the investment a sound one, and they would have their capital represented by assets with a reserve fund at the back of it. The Company, in his opinion, when Mr. Bannatyne was chairman, had been worked upon the plan of hoping and believing that the traffic would grow, and thus enable the Directors to lay by a good reserve fund. But the traffic had not grown, and the average of the few best selected years gave only £13,000. They had taken the average of the last three years, and two were of the better kind and one not so good, giving £12,700 odd of net revenue, as was shown in the Directors' special report. One gentleman had written them asking why they wanted to lay another cable. They did not want to do so, but they desired to have the money in hand to lay another cable if it was necessary to do so. They had estimated the life of the Barcelona cable at 25 years, and of the Bilbao cable at 20 years. Twelve years of the former and 17 of the latter had yet to run, and as nothing had been laid by to reserve hitherto, these calculations upon the life of the cables required £5,000 a year. He was satisfied that no one with any sense of responsibility, and the requisite knowledge for judging of the life of a cable, would say that the Directors had not done the best thing possible for the shareholders in taking these two terms of life. They had lost the original Bilbao cable. Fortunately for the Company the Eastern Company had two ships on their way from the Mediterranean. The Direct Spanish Company was not charged one shilling for bringing those ships to the ground where they had to work, and the two ships went to work in the most economical way possible, and brought home all the cable they could lift. Some part of the cable was brought home. That which had been put in of recent years was very good. The rest was being overhauled, and the whole expense of picking it up would be just over £7,000, perhaps not so much.

Mr. BAKER: Who made the cable?

The CHAIRMAN: The Silvertown Company. It was not the kind of cable they would lay in that depth of water. He blamed no one; but as he had said, the cable was lost, and the capital was gone. They had had one letter telling them that the Company was to be sacrificed to the Eastern Company, but he was quite sure that the gentleman—the writer—would not have said so if he had had sufficient knowledge to guide his judgment. As far as his opinion went, the Direct Spanish Company must have been in liquidation but for the joint-purse arrangement of the Eastern Company, which Mr. Gerhardi and himself made some years ago, and subsequent to that all the disaster of the broken cable had come upon them. That would have necessitated liquidation, or, if the concern had had to be set on its legs, it must have been at a dearer price than the Directors now proposed to pay by wiping off some of the capital. With that proposal carried he believed it would become a sound paying concern. They would thus lay by a reserve fund, and be able to reissue their debentures cheaper; but he reminded them that the scheme submitted by the Directors did not provide for any amortisation of debentures. They must trust to the growth of traffic to get funds for that purpose. The Directors had received proxies representing 800 votes. He concluded by moving the following resolution:—

"That in consequence of the abandonment of the Company's original cable, the capital of the Company be reduced from £190,000 (at present represented by 6,000 preference shares of £10 each, all issued and fully paid-up, and 13,000 ordinary shares of £10 each, whereof 12,931 are issued and have £9 per share paid up, and 69 are unissued) to £95,000, and that such reduction be effected by writing off £5 per share from the amount credited as paid up on each issued share, and £5 per share from the nominal amount of each unissued share, the amount so written off the issued shares being capital not represented by available assets."

Mr. ETLINGER seconded the motion.

The CHAIRMAN added that when he joined the Company he found the idea pretty generally prevailing that the assets would not fully represent the capital of the Company. He was, however, rather of a sanguine disposition himself, and Mr. Bannatyne would bear him out when he said that he at that time took a cheerful view of matters.

Mr. COCHRANE thought that the seven days' notice was very short for placing such a matter before the shareholders. He also inquired whether, by the conditions under which the preference capital was raised, they could force the preference shareholders to assent to the plan proposed.

The SOLICITOR, in reply, stated that seven days' notice was sufficient for any meeting held by the Company. As to the second question, the act under which they were proceeding was passed only ten years ago. It was not very clear what precise power there was in any individual case to object to the steps taken. He might say that the Directors anticipated that the question might be raised, and they would not be sorry if that were done, as it would make them perfectly clear, and save them from any anxiety in the future. Meanwhile, the first thing was to pass the resolutions at the two meetings—the present one and the one which would be called later—to con-

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firm what was done now. Then they would have to go to the Court for a resolution to reduce the capital. At that stage some shareholder might think it worth while to raise the question whether shareholders dissenting from the proposal could be bound by it. The resolutions would have to be passed now by a majority of three-fourths of those present in person or by proxy.

Mr. BANNATYNE said he was utterly unable to agree with the proposal. He held 100 ordinary and 100 preference shares, so that it would make no difference to him from that standpoint whether the motion was carried or not. He opposed the proposal because he considered it unjust, inequitable, and illegal. He should certainly not abandon any of his rights to a dividend of 10 per cent. upon his £10 preference shares. He could only be compelled to give way by the Company going into liquidation, and he would run the risk of that. He should take all legal means to defend his rights if necessary. He felt deeply for the ordinary shareholders; but the case of the preference shareholders was also a hard one. At the time the preference capital was raised it was of essential importance for the Company to have it, and it had to be all paid up at once. The subscribers thought they would get their dividends regularly, and they never imagined either that debenture holders would come in before them. He admitted that if they went into liquidation the preference shareholders would only get a *pro rata* distribution of the assets; but while they presented such a report as that which was submitted on the present occasion, they would not get from any Court power to go into liquidation. In regard to the prospects of the Company the Directors in their calculations were, he thought, very much on the safe side.

Mr. DYETT: Quite right; that is as it should be.

Mr. BANNATYNE: I admit that, but I am more sanguine.

Mr. LOW: You always were sanguine; and then the capital was lost.

The CHAIRMAN, in reply, stated that Mr. Bannatyne was for many years chairman of the Company, when the Directors issued 10 per cent. capital upon their poor little Company without telling the shareholders that there was the risk of the cables breaking, and that there was the certainty of the cables deteriorating; and no reserve was laid by at all. It was all stuff and nonsense for Mr. Bannatyne to talk about his conscientious objections to the proposal now made, and his pity for the shareholders. The proprietors' interests were not looked after at the time, no reserve fund being provided; and any man understanding anything about a cable knew that it was no property without a reserve fund at the back of it. In all that Mr. Bannatyne had said he had lost sight of the fact that half of the capital was lost, and that was the position that the "poor shareholders" were in. His own wish was to show them how they might get something, and how the concern might be made a living one.

Mr. BANNATYNE said that the Directors in his time did make some provision for a reserve, but it would be supposed from what the Chairman had said that they put by nothing.

The CHAIRMAN: When I joined the Board there was not £1,000 of reserve fund.

Mr. LOW: After being established twelve years.

Mr. BAKER said he considered the proposal so far as regarded the preference shareholders was most inequitable. The preference capital was raised for a specific purpose, which was now going on; and yet it was to be reduced equally with that of the shareholders. If the £1 a share liability on the ordinary shares was called up, and the £10,000 reserve fund was added there would be £23,000, and another £50,000 would lay a new cable.

The CHAIRMAN: Why lay another cable?

Mr. BAKER: To replace the one lost. He went on to argue that if that course was adopted, the position of the preference shareholders would be much better than under the scheme now proposed, the effect of which, he maintained, was to unduly depreciate the value of the preference shares, and, similarly, to raise the value of the ordinary shares.

Mr. LOW said he would assent to no arrangement other than that proposed by the Directors.

Other SHAREHOLDERS having spoken,

The CHAIRMAN, in reply, said the position of all concerned would be improved if they could put the Company in a dividend-paying position. Mr. Baker had more experience than himself of the Stock Exchange value of a thing, but for his own part he imagined that a £5 preference share, carrying a dividend of 10 per cent. would be worth more than £5 in the market; and, moreover, with the Directors' proposal carried, the preference shareholders would get £2 10s. per share at once for their arrears. The case of the position of the Anglo-American Company was different. The preference shares of that company were of a different kind to the preference shares of this Company. Adding together the £13,000 uncalled liability on the ordinary shares and the £10,000 of reserve fund, they were still a long way off the £60,000 which would be at least necessary to lay another cable. The longer, however, that they could keep their sovereigns at the bank the better. Reference had been made to the Directors only giving seven days to the shareholders to consider the matter, but that was long enough to read their proposals. The Directors, however, had been closely considering the subject for the last year or eighteen months.

Mr. ETLINGER said he had been a Director of the Company for twelve years, and he considered that the proposal now before the shareholders was the best in their interests.

The motion was then put and declared carried by 17 to 5.

The CHAIRMAN said he hoped yet to be able to "talk over" Mr. Bannatyne and Mr. Baker too.

The following resolution was then passed:—"That the Directors may make such regulations as they think fit for exchanging the certificates of shares for certificates in conformity with the foregoing resolution."

A vote of thanks to the Chairman and Directors brought the meeting to a close.

Maxim-Weston Electric Company (Limited).

An extraordinary general meeting of the shareholders of this Company was held on Monday, at the Cannon-street Hotel, under the presidency of Mr. H. Watt, M.P., for the passing of a resolution authorising the Directors to issue up to 100,000 shares, at not less than the par value of 5s. each, as, when, and how they might think fit.

The SECRETARY (Mr. Buchanan Cox) read the notice convening the meeting.

The CHAIRMAN reminded them that the last time he addressed them was in February, and in the ordinary course of events they would not have met again until next year. The exigencies of the Company, however, had rendered necessary the present meeting; but to explain fully the cause of the meeting it was necessary to refer to the events of three years ago. The then Board were authorised to issue up to 500,000 shares, but at a meeting held a year afterwards, from the suggestion of a shareholder of the Company, a moral pledge was given that they would not issue beyond 250,000 shares without the consent of the shareholders. It was owing to that pledge that they met now. There was nothing of a legal character about the pledge referred to, but the present Board were most reluctant to take any steps whatever which might, in the opinion of the shareholders, be calculated to be detrimental to the interests of the Company without taking them first into their confidence. The present number of the shareholders was 2,000, compared with 900 when the present Board took office—a sign which he always thought healthy. Many of them might not be conversant with the early history of the Company, and a short retrospect would therefore be beneficial. As some of the shareholders of the Company still possessed shares in the name of the Electric Light and Power Generator Company he might observe that that was the original name of the Company, which was established to work certain patents, but upon the purchase of the Maxim-Weston patents the title of the Company was altered as at present. When the present Board took office the capital of the Company was, if he remembered rightly, 172,500 shares of £1 each. But the capital existed only on paper. The amount paid for patents, &c., was about £130,000, but as to a portion of the purchase he thoroughly endorsed the action of the old Board in adding to the patents account the sum of about £60,000 for the purchase of the Maxim-Weston patents; in fact, but for those patents the Company would long ago have ceased to exist. The whole of the capital was virtually gone when the present Board took office, and they had to devise the best means they could to raise working capital to carry on the business. The expenditure of the Company, according to the balance-sheet of 1883, under the old *régime* was £16,000 to £17,000 per annum, and the revenue when he joined the Board was only about a fourth of the expenditure. The new Board had had a somewhat arduous experience, but he would pass over that with the remark that they had so far succeeded, and that the Company was now in a better position than it had ever been. He might say that the shareholders had such confidence in the old Board that when an issue of 77,500 shares was attempted they would take up only 2,000, though the price of issue was 5s. The present Board had to face the situation and find capital, which they did, with the result that at the end of that year the surplus was something in excess of £2,000. Having referred to the formation of the Lancashire Maxim-Weston Company, he reminded them that at the last meeting he told them that the factory accommodation which they then had, owing to the growth of their business, was entirely inadequate for the purposes of manufacture. He was happy to say that they had found premises at Dalston containing a superficial area four times in excess of that of the old factory, for which they paid only about 25 per cent more rent. They were now adding to their plant, with the view of manufacturing their heavier class of dynamos and plant. One essential necessity for manufacturing that plant was that Government contracts would only be given out to British companies manufacturing their plant here, so that there might be no necessity for going to America in the event of repairs being necessary. They would be in a position in a month or so to turn out any amount of plant up to an installation of 1,000 lights without having recourse to America at all. With regard to incandescent lamps, he said that it cost the old Board about 17s. 6d. to manufacture one, but under the present Board that price had been reduced to something like 3s. Unfortunately, however, the lamps did not possess the durability of American made lamps. He might say *en passant* that when the late Board purchased the Maxim-Weston patents they made a very good condition in insisting that the Company should have all improvements for five years in those patents without paying anything for them. It was unfortunate, however, that one point was overlooked—that they did not stipulate that the plant obtained from America should be purchased at 5 or 10 per cent. over the cost of manufacture; but they had now obtained from the American company a concession of something like 30 per cent. off what they charged for dynamos and lamps, as compared with what was paid before; and he calculated that by manufacturing their dynamos, &c.—in fact everything but incandescent lamps—they would effect a further saving of 25 or 30 per cent. If so, they would be able to compete with the very lowest prices in the market. Though the business done this year in volume—in weight of plant—had exceeded by nearly 50 per cent. what they did in the previous year, the value obtained had not been in the same ratio as before, although the amount had been larger. They were still subjected to what he would call competition of an unfair character—that was to say, competition on the part of persons or firms supplying plant at an absolute loss. He knew of one case recently where a contract had been made which must cause a loss of about 40 per cent. upon the price at which the plant could be laid down. This Company had undertaken nothing of that sort. He thought the amount of business they had done had been fairly satisfactory; but in these days of depressed trade they would agree with him as to the advisability of

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their being in a position to purchase their plant at the lowest possible price. They were constantly experimenting and trying to put themselves in a position to meet the requirements of their customers. The result of their experiments with their dynamo had been that, from the improvements they had effected, they were now able to produce with one dynamo 72 lamps, whereas before they could only produce 30 of the large—the old Maxim-Weston—lamps. The consequence was that they could produce plant to meet the lowest price of any opponent in the trade, provided that that opponent was securing for his manufacture a price which would leave him any margin at all. Alluding to the litigation in which the Edison and Swan Company had been engaged, owing to infringements of their patents, he said he was happy to state that the American Company had fought the Edison Company over their own lamp, and beaten them. Since then a new lamp had come into the market—the Weston wavy filament—which he claimed to be the most economical. He estimated that ten lamps would cost something like 1¼d. an hour, all plant and wear and tear included. He agreed that the Edison and Swan Company were right in defending their patents, considering the price which they, like this Company, had paid for them; but he thought they would have acted judiciously had they consulted with the Brush Company and this Company before engaging in the litigation referred to, so that the advisability of taking combined action might have been considered. He believed, had such combined action been taken they would have been successful against all comers, and that the large price which they had paid for their patents would not have been money thrown away. As it was, the competition of persons who had paid nothing for their patents subjected those companies who had paid heavily for theirs to a great disadvantage. In common with others they had received from the Edison and Swan Company a notice as to expecting a royalty, but he had no hesitation in expressing his belief that the patent which the Edison and Swan Company were now proceeding upon was the Sawyer and Mann, and in the litigation in America to which he had alluded, those interested in the Weston patent had maintained its position. That being the case, he entirely failed to see how the Edison and Swan Company could possibly have any action against this Company. No action had been taken against them by the Edison and Swan Company, and he thought that if it came to fighting, the Maxim-Weston Company would have the best of it. The Post Office installation had been going on very satisfactorily, with the exception that it was so huddled that the heat of the engine house was so great as to render the running unsatisfactory. As to their plant, different officials of the Post Office had intimated that nothing could be better. Since then he had secured several orders from the Government, and he was now in negotiation with a view of selling a considerable amount of plant as soon as they were able to send it out. The last important installation which they fitted up was at the Palace Hotel, Southport. Since that he was happy to say they had secured five contracts, and if they went on to the end of the year as they were going on securing work—and their present surplus was in excess of that at the corresponding period of the previous year—the capital which the proposed issue of new shares would produce would be absolutely required. He did not say that it would be necessary to issue the whole 100,000 shares at once, and they had no wish to issue one more share than was absolutely necessary. They had always worked on a very small capital. By the report of another company he saw that they had received no less than £120,000 in calls in one year. But the chairman of that company had expressed his opinion that the whole stock of the company was worth about £70,000, or £50,000 less than the calls of that one year had produced. The Maxim-Weston Company did not hold one penny in stock which was not saleable, and they were constantly economising in every possible form. If they could not work the Company so as to be of benefit to the shareholders he would no longer have anything to do with it. They had some very good contracts in hand, and there were some very large ones in negotiation, but they were not at present in a position to close a contract for £10,000. They had now a very large stock of plant—sufficient to despatch an installation of 1,000 lights within 48 hours; but they had only at the bank some £3,000 or £4,000, and in the event of their obtaining a Government contract for £5,000 that money would not be paid to them for probably nine months afterwards. He concluded by moving the resolution.

Mr. BROWN having seconded the motion, a discussion followed, principally with regard to the terms on which the new shares should be issued, it being contended by several speakers that it was only right that existing shareholders should have the first option of taking the new issue, and that the general public ought not to have them unless at a premium.

The CHAIRMAN pointed out that the resolution said that the new shares were to be issued at not less than the par value.

A SHAREHOLDER urged that the question of issuing further shares should be postponed until the next general meeting.

Another SHAREHOLDER thought that the issue might be limited for the present to 50,000 shares.

Mr. JACKSON argued in favour of the shareholders foregoing their dividends for a time so as to give the Company the working capital required, as constant issues of new shares depressed the market value of the existing shares. He thought an assurance ought to be given by the Directors that none of the fresh money to be obtained by the issue of shares should be used in litigation.

The CHAIRMAN, at the close of the discussion, in reply to questions, said he was informed that the original Edison patent expired in 1884, and therefore, as he had said already, he thought that the Edison and Swan Company must be going on the Sawyer and Mann patent. If so the parties in America who were interested in that patent contested every stage of the Weston lamp and failed. He sympathised with those shareholders who, like himself, had paid a heavy premium for their shares. He held more than 1,000 shares, which had cost him £1. 15s. each. He thought that the suggestion which had been made by more than one speaker was equitable, namely, that the shareholders should have the first opportunity of subscribing for the new shares. With reference to the remark about foregoing the dividend, the Board were in the hands of the shareholders. As he stated at the last meeting, however, there were a great many poor shareholders in the Company to whom a few pounds even were of value. If they did not approve of the issue of further capital it would naturally circumscribe the business of the Company. As to the amount of their working capital, he could not say exactly what it represented, not having taken stock since last January. Excluding outstanding debts, which probably amounted to £10,000, and taking the plant of the Company and the cash at the bankers, he should say that the available working capital was £25,000. That appeared a large sum, but they must take into account the fact that with every installation a third to a half consisted of plant to be bought, such as engines, cable, shafting, &c. That was the difficulty. He did not think they owed £300. If they only consented to an issue of 50,000 shares now the Board would have to come before the shareholders again, and however reasonable the ground was upon which Directors asked shareholders for capital, the tendency of a further issue, as had been stated, was to reduce the market value of the existing issue. It had been said that £100,000 had been lost by them. He was sorry to say that in his opinion that sum was much under what was actually lost. The present Board had had nothing to do with that loss. His views in regard to the enormous sums which were paid for their patents was that while the price might not have been in excess of their value in 1883, in the altered condition of circumstances in 1886 the value was absurd, and there was no reason why this Company should have continued to be saddled with a large amount of dead capital. The present Board came in as large shareholders to serve the interests of the proprietors generally, and he ventured to say that if the Company had been wound up in place of being carried on by the present Board they would not have got 6d. a share. With regard to litigation, his idea was that in the event of litigation being necessary the American Company would take the matter up. The last communication which he had received from the secretary of the Edison and Swan Company, however, was of the most friendly character, and from that he did not think they contemplated interfering with the Maxim-Weston Company.

The proposal that no capital should be issued until the annual meeting in January was then put and lost, and a similar result attended the motion to the effect that only 50,000 shares should be issued. Subsequently the original motion for the issue of 100,000 shares was carried almost unanimously, it being understood that the shareholders would have the first option of taking up the new issue *pro rata*, according to their holdings.

The proceedings then terminated.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. SEPT. 29.		BUSINESS DONE WEEK ENDING SEPT. 29. Highest.	Lowest.
Anglo-American	34,	35	35	34
Do. Preferred	56,	57	57¾	55¾
Do. Deferred	12½,	12¾	12¾	11¾
Brazilian Submarine	10⅜,	10⅝	11	10 11-16
Cuba	11,	11½	11½	—
Do. Preference	18,	19	—	—
Direct Spanish	1½,	2	—	—
Do. Preference	9,	10	9½	9½
Direct United States Cable	8⅜,	9⅛	8	—
Eastern Telegraph	11,	11½	11½	10¾
Do. 6 per Cent. Preference	14½,	15	14⅝	—
Do. 5 per Cent. Debentures, 1899	105,	108	—	—
Eastern Extension	11⅛,	11⅜	11⅜	11
German Union	9½,	9¾	—	—
Globe Telegraph and Trust	6⅛,	6⅜	6 7-16	6⅛
Do. Preference	13⅛,	13⅜	13 5-16	13
Great Northern	13½,	13¾	13½	13½
Indo-European	35,	36	—	—
Reuter's	6¾,	7½	7½	6¾
Submarine	195,	205	197	—
West India and Panama	⅝,	¾	¾	⅝
Do. 1st Preference	8½,	9	8¾	8½
Western Brazilian	6⅝,	6¾	6⅝	—
Western Union 7 per Cent. 1st Mortgage	118,	122	—	—
Do. 6 per Cent. Sterling Bonds	101,	103	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	13-16	15-16	—	—
Oriental	3-16	5-16	—	—
United Telephone	14⅜,	14⅝	14⅝	14⅜

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	2¼,	2⅜	—	—
Do. (fully paid)	4,	4¼	4¼	4 7-16
Swan	⅜,	1⅛	—	—
Maxim Weston	3-16	5-16	3-16	—

MISCELLANEOUS.

Telegraph Construction	39	40	39¾	39
India Rubber, Gutta Percha, and Telegraph Works	24	25	25	24¾

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NOTES.

THE WEST INDIAN LINES.—The cable between St. Vincent and Barbadoes is interrupted.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 1st inst. amounted to £4,375.

THE WEST COAST OF AMERICA TELEGRAPH COMPANY.—The gross earnings of this company for the month ended Sept. 30th were £3,585.

EASTERN TELEGRAPH COMPANY.—The traffic receipts of this company for the month of September amounted to £40,778, against £47,849 in the corresponding period of last year.

ELECTRIC LIGHT AT THE VATICAN.—We learn that Messrs. Siemens and Halske have received instructions to light the Vatican by electricity. The work is to be conpleted by the end of the year.

HALIFAX.—The Halifax Industrial Society have decided to light up their extensive premises by arc and incandescent lamps, and have entrusted the work to Messrs. Blakey, Emmott, and Co.

DIRECT SPANISH TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the month of September amounted to £1,751, against £1,793 in the corresponding period of last year.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY.—The traffic receipts of this company for the month of September amounted to £30,107, and to £41,845 in the corresponding period of 1885.

THUNDERSTORMS.—Heavy thunderstorms are reported this week from various parts of the country. In the Isle of Wight, the north of England, and the Glasgow and Edinburgh districts the storms have been of exceptional severity.

SIGNALLING ON MEN-OF-WAR.—A committee has been ordered to assemble at Portsmouth to consider the whole subject of mechanical, electrical, and voice communication between the decks and engine rooms of men-of-war.

NUREMBERG.—It is stated that the electric lighting of the Nuremberg theatre, which has been in hand for a considerable time, will not be completed for some weeks yet, "owing to the fact that the gas engine supplied was not nearly powerful enough."

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 1st inst. were £3,555, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

WEST AFRICAN CABLES.—The cable steamer "Dacia" arrived at the moorings off the Silvertown works on Sunday, the 3rd inst., after successfully completing her portion of the work in connection with the laying of the West African Company's cables.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic receipts of this company for September were £25,600, and the receipts for the period from 1st January to 30th September, £195,560; for the corresponding months in 1885 and 1884, £217,240 and £208,680 respectively.

TELEPHONIC COMMUNICATION BETWEEN PARIS AND BRUSSELS.—M. Granet, the French Minister of Posts and Telegraphs, is now in Brussels in order to discuss with the Belgian Government the terms of the proposed arrangements for connecting Paris and Brussels by telephone.

ANOTHER FORGED TELEGRAM.—At the Mansion House last week Henry Burnell was fined £5 for sending a fictitious telegram to a Mrs. Cooke to the effect that her husband had severely injured his hands.—In the Hammersmith case reported last week the offending woman has been fined £3.

TELEPHONY IN GERMANY. — The trunk line between Stuttgart and Heilbrow has proved to be a commercial success; the average daily number of communications now amounts to sixty. Lines have now been completed between Stuttgart, Ulm, and Friedrichsafen—a total distance of 200 kilometres.

THE TELEGRAPH CLERKS.—The Postmaster-General has replied to the telegraph clerks of the London Central Telegraph Office, in answer to their petition for a better scale of pay. He sees no reason for disturbing the classification of 1881, by which the staff of the central station received considerable benefit.

THE TELEPHONE IN BELGIUM.—The system of "delivering" telegrams by telephone (if the Hibernicism be permissible), which is being tentatively introduced in this country, has in Belgium become very widely employed. In that country, in the month of July last, no less than 31,812 telegrams were telephoned to their destination.

A CHURCH LIGHTED BY ELECTRICITY.—The church of St. Anne, Chasetown, near Walsall, which was built by the munificence of the late Mr. J. R. M'Clean, M.P., together with the National Schools, is now supplied with the electric light from the Cannock Chase Colliery Works, where an electric lighting plant has for some time been in use.

CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this company during the month of Sept. was 2,675, estimated to produce £2,250, against 2,583 messages, producing £2,160 in the corresponding month of last year. The traffic receipts for the month of June, estimated at £2,775, realised £2,767.

AN ELECTRICAL BALLOON.—The French Government have not yet given up the hope of finding a really successful method of steering balloons. At Meudon a very large balloon is now in course of construction; it is to be steered by means of a continuously-rotating sail-rudder, driven by an electro-motor, for which a primary battery will supply current.

THE SPRAGUE ELECTRIC RAILWAY SYSTEM.—Pressure upon our space this week compels us to hold over an important and interesting account of the Sprague Electric Railway system, which, it seems probable, will before long be definitely adopted for the New York elevated railways. We hope next week to be able to publish full details of the system.

BOOK RECEIVED.—From Messrs. Cassell and Company we have received a copy of "Electricity in the Service of Man, a popular and practical treatise on the application of Electricity This work is translated from the German of Dr. Alfred Urbanitzky, and edited with additions by Dr. R. Wormell M.A. The introduction is written by Prof. John Perry, F.R.S

SECONDARY GENERATORS POPULARLY EXPLAINED.—One of the Brussels daily papers thus expounds the theory of the action of transformers:—"They attract to themselves electric molecules which have been endowed with an alternating motion with high tension in the central cable, and they transform the said molecules into a small current of great quantity, but of less tension."

PROPOSED CENTRAL LIGHTING STATION AT TRENTE.—The Municipal Council at Trente has unanimously decided to introduce electric lighting, and has applied to the Government for the necessary authorisation. The River Fersina will furnish 600 available horse-power, and the engineer of the town estimates that the total cost of an installation upon this scale will not exceed £18,000.

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ELECTRIC LIGHTING IN BELGIUM.—The surface works of the Noël-Sart Colliery, at Gily, are now lit with four arc and 120 incandescent lamps. The current is supplied by two Crompton dynamos. At Antwerp Messrs. Beuckelair's large biscuit factory has recently been supplied with 18 arc and 400 incandescent lamps. The arc lamps are of low candle-power, and are worked upon the same circuit as the incandescents.

PROPOSED ELECTRIC RAILWAY AT LITTLEHAMPTON.—From a local journal we gather that at the next meeting of the Littlehampton Local Board plans for a proposed electric tramway are to be laid before the Board. The account from which we quote states that "Mr. Gantham, C.E., has prepared the plans, and Mr. Volk, proprietor of the electric tramway at Brighton, will, it is hoped, construct, stock, maintain, and work the electric railway."

FLUORESCENCE OF MANGANESE.—M. Lecoq de Boisbaudran has communicated to the Paris Academy of Sciences some interesting experiments on the "Fluorescence of the Compounds of Manganese subjected to Electric Effluvium in Vacuum." The fluorescence of some of the compounds of manganese is an extremely sensitive reaction, and the author of the paper considers that the method may be employed for the detection of minute quantities of the metal.

THE TELEPHONE IN SPAIN.—Six years ago the inhabitants of Bilbao applied to the Spanish Government for permission to supply themselves with a telephone exchange. The subject having now received due consideration, the necessary permission has just been granted. We learn that it is proposed to fit up a telephone for the use of any one of good position who asks for it free of all charge for one year, with the option at the end of that period of continuing it at a fixed tariff.

REGULATION OF DYNAMOS.—A recent American dynamo is regulated by the movement of the commutator. The commutator bars are set at a small angle with the axle of the machine, and thus if the commutator be moved longitudinally upon the axle the brushes slide from one bar to the next. It is not difficult to form an opinion as to the probable value of this device. The same object might evidently be obtained by sliding the brushes longitudinally instead of the commutators.

KING'S COLLEGE, LONDON.—Prof. W. Grylls Adams, F.R.S., will deliver a course of lectures on electricity and magnetism, and their applications to electric lighting, transmission of power, &c., at King's College, during the academical year 1886-7. A course of practical work in electrical testing and measurement, with especial reference to electrical engineering, will also be carried on under his direction in the Wheatstone laboratory. In the Wheatstone laboratory there are also special courses of practical work for students preparing for the science examinations of the University of London.

ANOTHER BRITISH EARTHQUAKE.—Information has been received at Lerwick stating that two shocks of earthquake had been experienced at Baltasnd Unst, Shetland, on Monday night. The first shock was felt at eleven, the other two hours later. Several people were roused from sleep by houses trembling and china rattling. Both shocks last several seconds; but no damage occurred to property. Baltasnd is situated in the Shetland Islands, and is the most northerly of Her Majesty's dominions. Twenty years ago an earthquake was experienced at the Flugga Lighthouse, Unst.

ELECTRIC LIGHT IN TEXTILE FACTORIES.—A prize of the value of £25 is offered by the *Deutsche Wollen-Gewerbe* (a journal devoted to the textile industry), for the best paper on the employment of the electric light in various textile works. The paper must deal in detail with the different systems of electric lighting, with the prime movers, and must also contain comparisons between oil, paraffin, gas, and electric light, with regard to first cost, working expenses, danger from fire, hygienic considerations, and the influence on the sight of the operatives. The papers must be written in German.

THE TIVOLI INSTALLATION.—This installation has now been brought into successful operation. It consists at present of about 200 Cruto lamps, each of 50 candle-power, 80 lamps of 16 candle-power (presumably Edison) which are used for lighting the public offices, and six Siemens arc lamps of 200 candles. Transformers upon the Gaulard-Gibbs system are employed, and the primary circuit extends over a length of 30 kilometres. The motive power for the alternating machine is derived from two turbines on the Tiber. This little town, which is not far from Rome, was previously lit by oil lamps.

POLICE TELEGRAPHS.—The commission of inquiry appointed after the riots in the West End which occurred in February last has just presented its report. Among other things they recommend that the system of police telegraphs which connects the principal stations in different parts of the metropolis should be largely extended, so as in effect to enable each police station to communicate with all others in the same district. They also recommend that every police officer be empowered upon due occasion to send an "urgency" telegram from any postal telegraph office, and that such telegrams shall have priority of transmission.

THE PARIS G.P.O.—Much disappointment is expressed that it should have been definitely decided not to light by electricity the new building for the Paris General Post Office. The architect has explained at some length his reasons for prefering gas, but they will scarcely convince any one not previously of the same opinion. M. Gaudet's idea that it is easier to "distribute" gas than electricity, of course, arises simply from want of information. His further argument that the methods of producing electric light continue to undergo unlimited improvement week by week is, we fear, equally fallacious. Considering that motive power is to be provided for other purposes, we certainly agree with the French journals that a mistake has been made in this matter.

ELECTRIC LIGHTING IN MINES.—Speaking at the recent meeting of the Montana Company, Mr. John Bayliss, in the course of his address to the shareholders, after his visit to the company's mines in America, said, referring to the introduction of the electric light, that the total cost of the installation had been 3,665 dollars, and that the cost per month for working, including maintenance and interest on the capital, was 250 dollars. The old system of lighting cost 500 dollars per month, so there had been a saving on this item of 3,000 dollars a year on an expenditure of 3,665 dollars. Beyond that there was the untold saving arising from their comparative immunity from fire by the electric light, compared with their position under the old system of oil and candles. It was intended to extend the installation to the new 60 stamp mill, but the cost would not exceed 1,200 dollars.

ELECTRIC LIGHTING IN GERMANY.—A company calling itself the North German Electrical Works has just completed its first central station in Hanover. Electricity is supplied to customers who undertake to subscribe for three years, payment being by meter at the following rates:—·42 pence per lamp hour for a 10-candle lamp, and ·5 pence per lamp hour for a 16-candle lamp. It is proposed to light the river docks at Frankfort with four arc and 280 glow lamps. The first cost is estimated at £2,200, and the working expenses at £160 per

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annum. Since the beginning of the autumn season, with the 1st of September, the town theatre in Cologne has been lighted by electricity. This installation was planned and carried out in the short space of eight weeks, and has worked from the first without a hitch. It has been undertaken by the Gas and Waterworks Company of Cologne, and the same company is now preparing plans for a central station in Cologne.

"SQUAWKERS" FOR EXPERIMENTS IN STATICAL ELECTRICITY.—It is possible that some of our readers may not be familiar (by name at least) with the instrument of torture known in the States by the onomatopoetic and euphonious name of "squawker." They are, however, exceptionally fortunate if at some period of their existence they have not been exposed to its distressing effects upon the auricular nerves. A squawker is a small india-rubber bag, which, being inflated by the the lungs of a small boy, emits a dismal and discordant shriek while the air issues through a wooden pipe. The *Scientific American* recommends the employment of this apparatus in place of the traditional pith ball for illustrating the phenomena of statical electricity. If two or three such balls be inflated they can readily be electrified by stroking with a cat-skin, and may then be floated in the air. A number of interesting and instructive experiments with this apparatus will readily suggest themselves.

THE CONSTITUTIONAL CLUB.—The new and palatial building of this club were opened on Monday last. The architect for the work is Mr. R. W. Edis, F.S.A., and the façade forms one of the most striking features of Northumberland Avenue. A unique arrangement has been adopted in the artificial lighting. Incandescent electric lights are fixed in the ceilings, and so arranged as to harmonise with the treatment of the decorations. In the day time the means of artificial lighting are effectively concealed; while at night the uniform glow, distributed from the ceilings throughout the whole area of the rooms, forms the nearest possible approach to daylight. The electric machinery is erected in the basement of the building, both the engines and the dynamos being in duplicate. The idea of lighting the building in this manner originated with the architect, and has been efficiently and completely carried out by Messrs. B. Verity and Sons, of Covent Garden, who have also just lighted the Junior Carlton Club.

THE EXHIBITION AT THE PALAIS DE L'INDUSTRIE.—The following is a list of the more important electrical novelties which are to be seen at the Exhibition of Arts and Sciences at present being held in Paris:—New dynamos by Scrive-Hermite and one by Mondos; a machine exhibited by the Société Centrale d'Electricité, and an alternating current machine by M. Goulard; primary battery designed for electric lighting by M.M. Goodwin, Buchin, and Tricoche, and one by M. Lagarde; secondary batteries by Julien (designed for electric traction) and by M. Reynier; a secondary generator by M. L. Clerc; a coulomb-meter and watt-recorder by M. Jacquemier; an alternating current recorder by M. Cauderay; incandescent lamps by M. Lodyguine and by M. Werndl; arc lamps by M. Clostermann and by M. Pieper; electric tramway on the Julienne system; a long distance telephone transmitter by M. Ader; and a model of a species of telpherage system by M. Radiquet. We hope shortly to give detailed accounts of such of these exhibits as seem likely to become of any practical importance.

ELECTRIC LIGHTING AT LISKEARD.—The *Western Morning News* of the 4th inst. contains the following:—"Liskeard was on Saturday evening illuminated by the electric light for the first time. Eight arc lamps of 1,200 candle-power each were used in an area comprising the Parade, Pike-street, Market-street, Fore-street, Bay Tree-hill, and Barras-street. The experiment was most successfully conducted under the superintendence of Mr. Wharton, of the firm of Laing, Wharton, and Co., assisted by Mr. Perrott. The light was most brilliant and steady throughout. The streets were crowded with sightseers, all of whom were loud in their praise of the arrangements, and many expressed the hope that the light might become a permanent institution. This evening some of the shopkeepers will have their establishments lit by electricity, and it is intended that lights shall be generally distributed in the various shops during the next three weeks. On Thursday Mr. Wharton will deliver in the Guildhall a lecture on electric lighting. The Mayor will preside. The hall will be suitably lit for the occasion. On Friday week the parish church will be illuminated for the harvest festival service."

SELF-INDUCTION IN VOLTMETER COILS.—In reply to a correspondent, M. Hospitalier gives the following experiment, to illustrate the effects of self-induction in the coils of a voltameter:—Place in circuit an incandescent lamp, an electro-dynamometer, a resistance without self-induction, and an alternating current machine, and connect the voltmeter in parallel with the lamp. By adjusting the speed of the machine and the value of the resistance, bring the lamp to its normal luminosity; note the readings of the dynamometer and the voltmeter. Now increase the speed of the machine, and by adjusting the resistance again reduce the lamp to normal incandescence. The dynamometer reading will be the same as before, but the voltmeter reading will be smaller. The greater the increase in the velocity, the greater will be the difference between the two readings of the voltmeter. Are we to imagine that the number of watts consumed in the lamp is different in the two cases? Certainly not. We are simply to conclude that a voltmeter containing a coil inductively-wound, especially if there be also a soft iron core, is utterly useless for measuring alternating currents.

USE OF THE MICROPHONE FOR DETECTING LEAKAGE.—The microphone has several times rendered important service in the United States in the detection of the exact locality of a leak in an underground water main. Experiments have recently been carried out in Germany by some of the water companies, with the result that the instrument has been definitely adopted for the purpose as a part of the regular equipment of the companies. The apparatus consists of a microphone of any ordinary construction, a dry battery, and a telephone. It is used principally for the detection of badly-fitting water cocks. When the microphone is placed upon the cock it is stated that a leak of only one or two drops per second causes sufficient vibration of the metal to give perfectly distinct indication in the telephone. We are pleased to hear that experiments have proved the method to be successful in practice. We should almost have been inclined to fear that at any rate in large cities, where so many "earth" connections are made with gas and water mains, a telephone in the immediate neighbourhood might frequently be influenced by direct induction from currents in the mains themselves.

GLASGOW COLLEGE OF SCIENCE AND ART.—We observe from the syllabus of the Glasgow College of Science and Art that the winter session commences this week. Both day and evening lectures are given in magnetism and electricity, and electrical engineering; and an important step has been taken in the establishment this session of an honours practical class for electrical testing and research, under the direction of Principal Jamieson and his assistants. This class has been started with the view of enabling young electrical engineers

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to become familiar with the scientific apparatus and tests so very necessary in connection with their profession. The Glasgow College has had a remarkably successful career. At the last May examinations of the City and Guilds of London Institute one of the students gained the first place in honours, with £5 and silver medal, in telegraphy, while another took the second place in the ordinary stage, and a third the second place in the same stage in electric lighting and transmission of power. The science and art passes, combined with the six Whitworth scholarships, seem to have been largest from this than from any other technical institution in the kingdom. The John Pender gold medal has been carried off by John Macfee, jun., superintendent of the Paisley Telephone Branch of the National Telephone Company's Scotch system.

THE CANADIAN PACIFIC TELEGRAPH SYSTEM.—The *Electrical World* says:—The opening of the Canadian Pacific Railway's telegraph took place September 13, with a through line from Montreal to the Pacific coast, and with a maze of branch lines, giving connection with all centres of trade and population in Canada. On commencing operations the company will have four direct wires between Montreal and Winnipeg, two of which will be used for the movements of trains and other railroad matter. This will leave two wires for commercial business. The wire used in this gigantic circuit is No. 6, and is of a grade particularly designed for long circuits. It was imported from Germany, where it was manufactured under the specifications adopted by the company as a standard. Before the wires of the company were completed right through to Winnipeg the opinion was expressed that, despite any precautions which could be taken, it would be impossible to operate this circuit of 1,422 miles without the use of at least four repeaters. But, as a matter of fact, only one repeater will be required, and even this will be dispensed with in clear, dry weather, such as generally prevails during the winter. The company makes connections at Richford, Vt., and Morristown, N.Y., with the Postal Telegraph Company of the United States.

PROJECTED ELECTRIC RAILWAY IN BUDA-PESTH.—A correspent of *Industries*, writing from Vienna, says:—Within the last few years the town of Buda-Pesth has developed at a very fast rate, and the present means of communication are beginning to be inadequate. An electric railway has been proposed, which is intended to connect the central parts of the town with steam tramways in the suburbs. The project is for a double line, about three miles long, part of which will be laid along the lower embankment of the Danube, on an iron viaduct. The existing traffic and the view to the river will not be impeded, there being a clear headway of 12ft. 6in. between the ground and the under side of the girders on which the viaduct is supported. That portion of the line which crosses the Franz Josefs-square will be underground, the head of rails in the tunnel being 13ft. below the pavement. Since at so small a depth there would be no room for masonry arches, it is proposed to form the ceiling of the tunnel of iron girders, which will rest on the side walls, and be supported in the middle by a row of columns placed between the two lines of rails. The maximum gradient is 21·7 per thousand, and the sharpest curve will have a radius of 150ft.; each car will have its own electromotor, and the rails are to be used for the out and home circuit. The current will be supplied by fixed engines and dynamos.

SOME NEW LECTURE EXPERIMENTS.—Under the title of "New lecture experiments upon the transportation of electric energy," *l'Electricien* describes several interesting and instructive experiments with induction coils. To illustrate some of the effects of self-induction the following arrangement is suggested. A battery which is capable of supplying a sufficient number of watts to light up a small incandescent lamp, but which at the same time has not sufficient E.M.F. to do so under ordinary circumstances, is joined up with the primary of an induction coil, the latter being provided with the usual vibrating break. The lamp is connected as a shunt across the terminals of the coil, the secondary circuit in this case remaining unclosed. As soon as the current is switched on, the "extra current," due to the self-induction of the coil, will light up the lamp. To make this experiment successful, the total volt-amperes in the primary circuit must clearly, however, be considerably in excess of that required by the lamp, and the condenser should also be disconnected. The action of transformers and the phenomenon of mutual induction may be conveniently illustrated by means of two similar Rhumkorff coils. The secondary circuits having been connected together, a battery is placed in circuit with the primary of the first coil, and the vibrator of the second is screwed down. The current generated in the primary of the latter coil then illustrates the action of the secondary circuit of a transformer.

CITY AND GUILDS OF LONDON TECHNICAL COLLEGE, FINSBURY.—The Old Students' Association of this college held its first annual dinner on Friday last at the Duval Restaurant, Strand. A distinguished company, numbering over sixty, of members and friends interested in the welfare of this young and flourishing association, was present, under the chairmanship of its first president, Mr. H. Newman Lawrence, and included Prof. S. P. Thompson, D.Sc., Principal of the College, Prof. J. Perry, F.R.S., Prof. Meldola, F.R.S., Prof. W. E. Ayrton, F.R.S., and Prof. H. Armstrong, F.R.S., of the Central Institution; Mrs. Ayrton, the Rev. T. J. Lawrence, M.A., L.L.M., Camb. University Extension Lecturer, Mrs. Mercer, and others. The after dinner proceedings were most enthusiastic, the toasts of the "Technical College," proposed by the chairman, and responded to by the Principal, and the "Old Students' Association," proposed by Dr. Thompson, and responded to by the President and the president-elect (Mr. A. Chatterton, B. Sc.), were especially well received. It is needless to say that with the gentlemen named above present many excellent speeches were made, and a most enjoyable evening spent. It was announced that the silver medal of the association for the best paper read at the discussion meetings has been awarded to Mr. A. W. Slater, for his paper on "Torpedoes." Such a cordial and enthusiastic gathering of professors and students, past and present, speaks well for the internal working of the educational system, inaugurated and so well maintained by the City Fathers, and we heartily wish the Old Students' Association continued and increased success.

HAVANAH-KEY WEST CABLES.—The Silvertown Company has received a telegram from Mr. Theophilus Smith, engineer-in-charge of the cable steamer "International," announcing the completion, on the 4th inst., of the repairs to the duplicate cable between Havanah and Key West. These repairs give the International Ocean Telegraph Company, of New York, a practically new cable from end to end, as the part untouched by the "International" was laid during repairs carried out within the last two or three years. The type of cable employed is specially protected to withstand the corrosive action of the bottom on the sheathing, this action having been very noticeable in the cable hitherto laid in this locality. Although more than ordinary care has been exercised in the relaying, it is impossible to free this cable from the danger of damage from the hot pitch springs met with on the north coast of Cuba, in depths ranging up to 800 and 900 fathoms. The operations completed were of no ordinary character, as a large

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portion of the work was carried out in the axis of the Gulf, where, dependent on the winds to a great extent, the current varies from half a knot from the eastward to over five knots from the westward, the normal direction of the flow. Mr. Theophilus Smith has had the advantage, during the operations, of the local knowledge of Mr. M. L. Hellings, who is cable manager of the International Ocean Telegraph Company, and who has either superintended or has been present at every repair to this company's cables during the last twelve or fourteen years. Mr. March Webb and Capt. Wilson-Barker, R.N.R., were respectively chief electrician and commander on board the "International."

AN ELECTRIC LOG.—Some few weeks ago, in the columns of a recently established contemporary journal, we noticed an account of a newly invented ship's log, in which electricity played the part of a recording agent. The device was ingenious, but as it did not appear to have been carried into practice we did not consider the paragraph worth reproducing. We have since learnt that the same, or a very similar device was actually employed, as long ago as 1882, on board some of the ships of the Compagnie des Messageries Maritimes. This earlier electric log was the joint invention of two officers of the company, Captains Fleurias and Bretel. It consisted of a screw, having several blades, which, when thrown into the water and dragged behind the ship, revolved in an open framework. An insulated wire was connected with this frame in such a way that at every revolution of the screw contact was made with the extremity of the wire, and a circuit was thus closed through the water to the ship. The circuit was completed on board by means of a battery and a telephone. Knowing the number of revolutions of the screw corresponding to any required distance traversed, it was easy to obtain the rate of sailing by listening at the telephone, and counting the number of contacts made during one minute. This arrangement seems to have been quite successful in action, although we do not know whether it is still in use. The more recent invention referred to above differs only in respect to the manner in which the number of revolutions of the screw is ascertained, and in this respect it is certainly an improvement. The telephone is replaced by an electro-magnetic speed counter, which receives a step-by-step movement every time the circuit is closed. We see no reason why these devices should not be perfectly successful and reliable in operation, and they might well supersede the primitive method of counting the time-honoured "knots" as the line slips through the seaman's hands.

THE BRUSH MOTOR.—The Brush Electric Company are now manufacturing at their Cleveland works an electro-motor which is electrically the counterpart of the well-known Brush dynamo. The regulation is effected mechanically by a somewhat novel method, which is described as follows:—A centrifugal governor is provided, consisting of a metallic shell securely bolted to the armature shaft. To the inner periphery of the shell are pivoted on opposite sides of its centre two governor arms, the inner and free ends of which are connected to the opposite arms by spiral springs. On each of the arms are placed adjustable weights. To the arms near their free ends are pivoted links, the opposite ends of which are connected to the commutators; the latter are set loosely on the armature shaft. As the governor shell rotates with the armature shaft, carrying with it the parts described, the weights will at a certain speed be moved by centrifugal action towards the periphery of the shell, and through the medium of the connecting links will impart a rotary adjustment to the commutator, varying its position in the armature shaft. When the motor is at rest, the spiral springs will retain the weights in close proximity to the shaft and the commutator, at the extreme limits of its rotary adjustment in one direction, and the brushes will bear on the maximum points of the commutator. When current is switched into the motor, rotary motion is imparted to the armature and its shaft, the speed of which gradually increases until it has attained its normal velocity, when the governor weights will begin to recede from each other, and rotate the commutator on the shaft carrying its maximum point away from the contact of the brushes. This action decreases the effect of the current until a point is reached where this effect is balanced by the load on the motor, and the speed remains constant. On the other hand, should the speed of the motor be retarded by an increase of current or an increase of load, the governor weights will be drawn towards each other by the spiral springs, and thereby rotate the commutators in the opposite direction, the effect of which is to move the maximum points nearer to the brushes, and thereby increase the speed. The direct connection of the governor with the commutator would seem to ensure prompt adjustment of the latter without loss of motion, and at a minimum expense of power.

ELECTRIC LIGHTING IN LEEDS.—The *Leeds Mercury* of the 30th ult. contains the following:—"This system of lighting is being rapidly pushed forward in Leeds, and apparently with good results. The new building of Messrs. Goodall, Backhouse, and Co., White Horse-street, Boar-lane, has been furnished with the electric incandescent lamps, as also have several parts of the old building. The installation consists of one of Crompton's compound self-regulating dynamos, and some 300 16 candle-power Edison-Swan incandescent lamps of 110 volts each. The dynamo is a very powerful and substantial-looking machine; and the field-magnets are made of the best soft wrought iron, planed all over, and polished bright. It is driven from a countershaft by a pair of engines with cylinders 14in. diameter, 28in. stroke, capable of working up to 100 horse-power. The machine is run at a speed of 525 revolutions per minute. In arranging the power it was at first thought that accumulators would be absolutely necessary, on account of some 80 to 90 lights being occasionally required after the main engine stopped. This difficulty, however, Mr. Wilson Hartnell surmounted by putting down an auxiliary engine, and this at about one-fifth the expense. The latter is one of Turner's 4 horse-power (nominal) vertical engines, fitted with Hartnell's patent governor. It is arranged to drive on to the same countershaft as the main engine, and a fast and loose pulley are provided for each. It can be started before the main engine stops to maintain a continuous light. In the main driving belt provision has been made for transmitting upwards of 300 horse-power. The main switch-board (Hartnell's patent) is fixed near the dynamo. They are double-pole switches with quick action, and the making or breaking of the contact is done instantaneously on both the positive and negative wires at the same time. Double-pole cut-outs are also provided, as well as a small fusible cut-out to each lamp in the branch leads and at the main junctions. In the offices the lamps are suspended by silk flexible cords from ceiling plates, corresponding with the ornamental ceiling. Each lamp is fitted with suitable shades, and the whole has a very pleasing appearance. The electrical work has been carried out by Mr. Wilson Hartnell, consulting engineer, Leeds; and we are informed that the work has given satisfaction to all concerned." We recently had the pleasure of looking over this installation, and fully endorse the above commendation. All details, both as to design and execution, have been thoroughly well worked out. It may be added that the engines are by Messrs. Mann and Co., of the Elland-road Works, Leeds.

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INSTALLATION AT WENTWORTH CASTLE.

The owners of valuable pictures, and rare books, as well as the owners of expensive furniture and elegant fittings, and those who live in houses highly decorated, have each and all a distaste for gas. Many refuse to use it, and have hitherto trusted to candles or oil for artificial light. The cry of the age is for more light – more light physically as well as mentally. Nature never intended that man should emulate the cat, and try to gradually evolve a different type of eye. Yet this seems to be the usual plan. Darkness made visible is applicable to the state of many a dining and drawing room. Surely numbers of eyesights suffer from the stupidity that prefers three or thirteen candles to four or forty, or too little light instead of sufficient. If work is necessary after the sun is down, that work be it reading, sewing, drawing, or factory work, should be performed in as good a light as can be obtained. It may be said that gas will give all that the electric light will give, but this we firmly and emphatically deny. The adoption of the electric light at Wentworth Castle and similar places will assist to dispel the illusion. Gas at its best is a bad medium for lighting, and can hardly be said to be comparable to the incandescent electric light.

Fig. 1.—Wentworth Castle.

Wentworth Castle (Fig. 1), near Barnsley, the seat of Thomas C. F. Vernon Wentworth, Esq., has recently been lighted throughout by the electric incandescent light, by Mr. Wilson Hartnell, M.I.M.E., of Leeds.

The electric light installation consists generally of the engines and boilers, dynamos, and everything complete. The whole installation consists of over 500 lights, with provision for 600. As an example of the application of the electric light to a large mansion we think it sufficiently interesting to give a description in detail.

Commencing with the machinery, there are a pair of 12 horse-power Cornish boilers, by Marshall and Sons, of steel, of most modern construction, all the holes being drilled, the flues strengthened by Adams's seams throughout, and suitable in every way for a working pressure of 80lbs. The boilers are 14ft. 9in. long, 5ft. 3in. diameter, with a 2ft. 10in. flue. All the rivet holes in the boilers were drilled by special machinery, and the boilers tested by hydraulic pressure to 160lbs. per square inch. They are provided with a full set of steam and furnace fittings and mountings. For supplying the boilers with water a No. 5 Giffard injector and a No. 0 Blake boiler feeder are used, each with suitable connections, and either of these is capable of feeding both boilers if required. Figs. 2 and 3 show a plan and an elevation of the dynamos and engine.

A large tank has been specially provided for the water supply. The chimney is of wrought iron, placed near the trees, so as to be as little prominent as possible. It rises without stays from a stone basement, to which it is secured by bolts of some 13ft. in length.

The engines are horizontal (Fig. 4), with cylinders 10½in. diameter, 16in. stroke, fitted with Hartnell's patent automatic expansion governor. The speed is 140 revolutions per minute, at which they will indicate 35 horse-power, each cutting off at about one-third the stroke. The engines drive a steel countershaft,

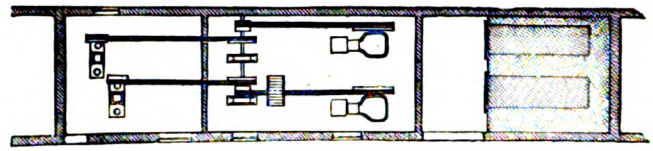


Fig. 2.—Plan.

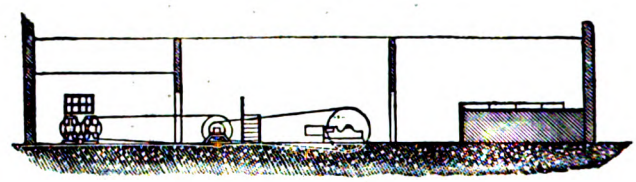
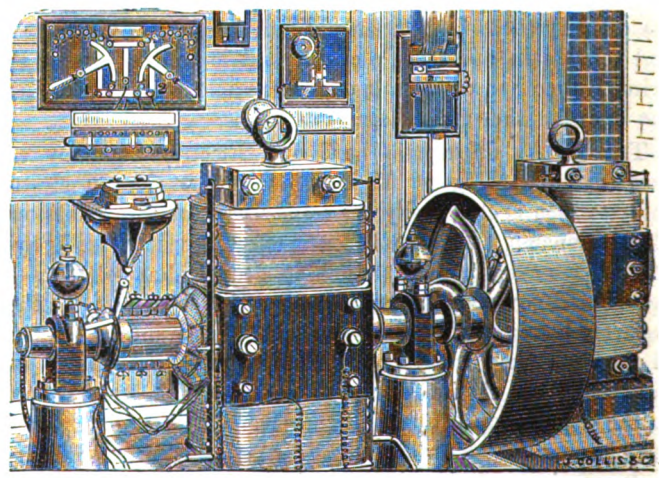


Fig. 3.—Elevation.

running in phosphor-bronze bearings, the latter carrying four pairs of fast and loose pulleys, two pairs of which are for the dynamos and two pairs for the engines. The object of this arrangement is that either or both engines can drive either or both dynamos, and either can be stopped or started independently of the other. We may remark that the engines and dynamos are in duplicate, each set being capable of working about 300 lights. The whole of the machinery is fixed on heavy stone foundations. The dynamos are two 15-unit Crompton compound-wound machines of the slow-speed type. There is a novelty in the winding and the coupling of these machines. The compound winding is such that the E.M.F. with a constant speed rises with the current to allow for the resistance of the main leads, the total rise with the maximum 320 amperes being from 110 to 134 volts, so as to maintain a constant E.M.F. at the castle. This includes an allowance due to the estimated reduction in the speed of the engine with a heavy load. A special method of coupling the dynamos had to be adopted owing to this variation of the E.M.F. (which shall hereafter be described), so that one dynamo could be started or stopped whilst the other was at work without affecting the E.M.F.



Dynamo Room—Wentworth Castle Installation.

The dynamo main switch-board consists of a black enamelled slate, carrying one of Hartnell's patent compound switches (Fig. 5) for each dynamo. Each switch has eight contact terminals, six of which make or break contact in stopping or starting the dynamo. The advantages of these compound switches over a large number of independent switches are that by one switch all the shunts or circuits necessary to be made or broken in

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starting or stopping a dynamo are effected by one movement in the proper manner and in their right order. No mistake being possible, no skilled manipulation is required. By a further movement of either of these switches the current of

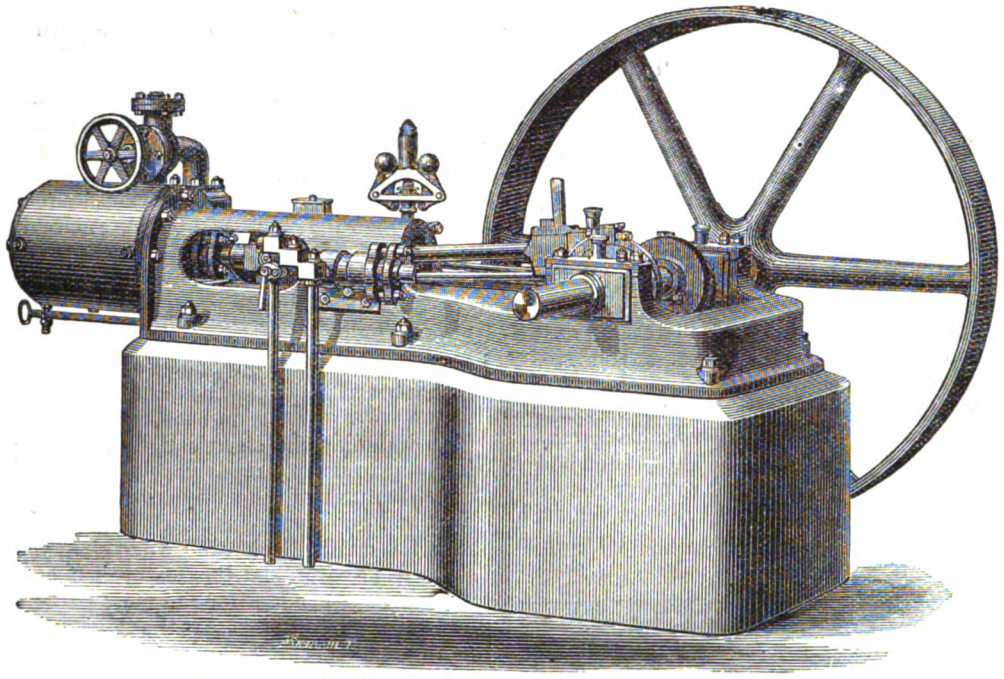


FIG. 4.—Marshall's Engine, Wentworth Castle Installation.

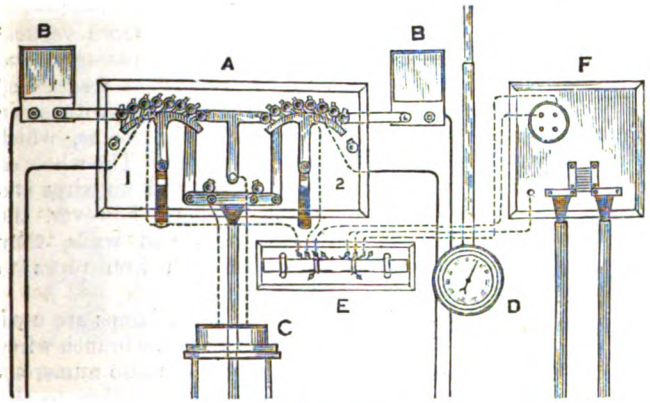
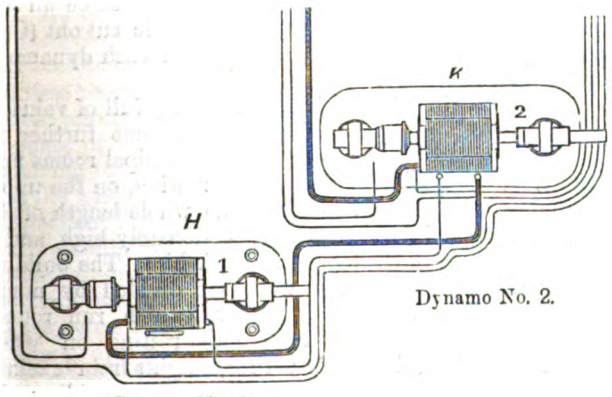


FIG. 5.



Dynamo No. 1.

In this figure A represents the compound switch, C the Crompton-Kapp current motor, D the Cardew voltmeter. E is the voltmeter switch-board, and deserves some explanation. It consists of a positive and negative brush, which by means of a slide can be connected to either of four pairs of positive and negative brushes. Thus the E.M.F. can be measured at either dynamo, at the Castle distributing board (by means of a pair of wires laid with the main cables), and at the local circuit. F is the negative board; it carries a fusible cut-out on the negative cable. G (Fig. 5A) is the E.M.F. regulating switch; its use is to maintain a constant E.M.F. at the Castle, notwithstanding any disturbance due to the lights on the branch cable leading to the stables, &c., and other purposes. The variations due to the Castle itself are provided for in the compound winding. This regulating switch-board carries two resistances, one for each dynamo, through which the current round the dynamo shunt travels. By means of a slide and two brushes, and 32 small terminals to each resistance, the resistances may be cut out 1-3rd at a time. H and K show a plane view of No. 1 and No. 2 dynamos, with a diagrammatic representation of the connection. It must be remembered that these dynamos are not compounded to give a uniform E.M.F. irrespective of the current. On the contrary, the E.M.F. varies with the current, and is constant 300 yards away at the Castle. Thus the ordinary methods of coupling dynamos in parallel would fail in this case. The return wire passes first to dynamo No. 2. The return current traverses No. 2 (in four parallels) and then passes to No. 1 dynamo, which it similarly traverses, and is there at liberty to return to the negative brushes of either or both dynamos. The details of these connections can be readily thought

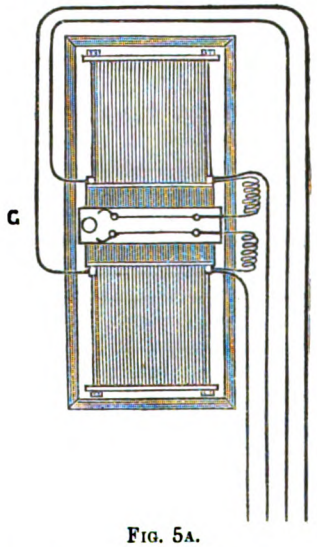


FIG. 5A.

out, but would be tedious to minutely describe. The shunt wires, as before stated, start at the 5th brushes of the switch, and thence pass to their respective resistance coils in the regulator G, and then return to the positive ends of their own dynamo coils. Thus each dynamo is similarly excited, whatever be the E.M.F. or the current in the main cables. It may be noticed in passing that the same result might have been produced by the return current being equally divided before passing to the coupled negative brushes. In either case the series coil of the dynamos must be large enough to carry twice the current it is intended to produce. In like manner, if three dynamos with a rising E.M.F. had to be coupled, the series wires must carry three times the current generated by each dynamo, and so on.

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either dynamo can be separately measured. There is also a small switch-board connected with the voltmeter for measuring the E.M.F. of either dynamo, the E.M.F. at the castle, and the E.M.F. of the lamps in the immediate neighbourhood. A branch is taken off from the main cable underground for supplying the outbuildings. This branch necessitates making a further adjustment of the E.M.F. at the dynamo to keep it constant in the castle. This is effected by a variable resistance in the shunt coil of each dynamo, which can be simultaneously adjusted by a small switch-board, having 36 terminals to each resistance, so that the same adjustments serve for either or both dynamos. This resistance will be automatically worked by Hartnell's patent electrical governor. It will be noticed that this governor has only to correct small differences of E.M.F., due to several disturbing causes, the adjustment for the most part being effected by the compound winding and Hartnell's automatic expansion governor on the engine.

Fig. 6 shows the compound switch-board. The main switch-board A carries two quadrant switches, No. 1 and No. 2. The diagram shows each switch turned fully. Above each quadrant are eight copper brushes, seven of which rest on the quadrants. The brushes are carried on suitable terminals, with connections behind the switch-board. The switch-boards are all of black enamelled slate. The eighth or outer terminals are connected with dynamos No. 1 and No. 2 respectively. The fifth terminals are connected to the positive ends of the shunt

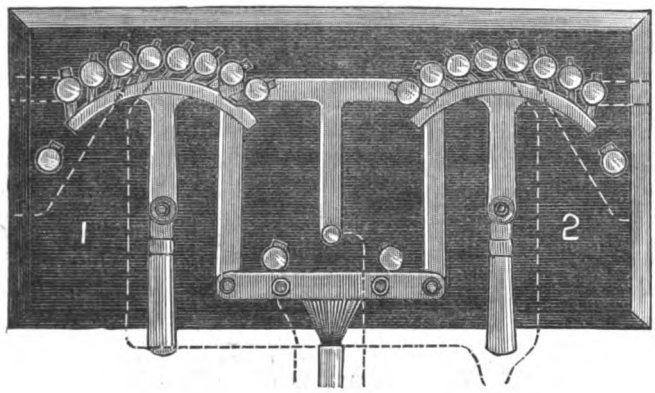

Fig. 6.

wires of their own dynamos. The second terminals are connected to the positive main cable. The first terminals are connected to a T piece, and are used for shunting the current through the current meter by an outer movement of either quadrant, which brings the first brush into contact, and at the same time moves a recess in the quadrant under the 2nd brush, thus breaking the direct connection with the main positive cable. The intermediate terminals are coupled to each other through resistance frames, the object of these being, that if the switch be turned off with the full load on, no risk of damage is incurred by the dynamos. On turning off the switch, when the quadrant leaves the 8th brush the current is shunted through about 2-3rd ohm; on leaving the 7th brush the current is shunted through an additional 2 ohms; on leaving the 6th brush the main current, now reduced, say, to 30 amperes, is broken. When the quadrant leaves the 5th brush the dynamo shunt current is shunted through 30 ohms; and on leaving the 4th brush it is shunted through an additional 30 ohms; and on leaving the 3rd brush the dynamo shunt current is broken. To start the first or either dynamo, its switch must be placed in the upright position shown, thus connecting its shunt wire with its positive pole. The second dynamo started becomes fully excited when its quadrant switch has reached the 5th brush, which connects its shunt to the already positively excited cable.

The main cables to the castle switch-board are composed of 19 strands of No. 10 wire of Callender's most highly insulated cable, and is laid on bituminised wooden supports in a wooden trough filled in with bitumen, the whole being buried in the ground, the cable from switch-board to switch-board being 295 yards (*i.e.*, 590 yards in all). A pair of small wires are laid with the main cable, in order to measure the E.M.F. at the castle, in the dynamo house, and actuate the electrical governor.

The castle is a quadrangular building (see Fig. 1) with a central court; the east and south faces are each about 160ft. long, the western and northern being shorter.

The main leads from the switch-board are as follows:—

			Lamps.
East wing.....	1	North Grand Hall, &c....	73
,, ,,	2	South ditto, &c.	35
Ditto upper floors...	3	North Picture Gallery, &c.	53
,, ,,	4	South ditto, &c.	54
South wing	5	South circuit.....	63
West wing	6	West circuit	49
North wing	7	North circuit.....	73
			400

The distributing switch-board contains seven switches, with provision for eight, on a cast-iron base; there is also a negative switch-board of enamelled slate for the purpose of isolating the negative wires or measuring the current on either circuit.

In designing the electric light fittings great care was taken not only to make them suitable to the architectural or decorative features of the various rooms, but also to make them as light and unobtrusive as possible. The glow lamp, only weighing a few ounces, looks well when simply pendant from its own conducting wires, and this feature has been retained in all the upper rooms, pendant for the most part from light brackets on the walls. In several cases the brackets are floral designs, of light, simple character and graceful form, and free from superfluities, but of the best workmanship, by Messrs. Faraday and Son.

The general distribution of the wires is as follows:—The leads go direct from the switch-board to one or more vertical wires in each wing, with branches through the passages, and branches again into the various rooms, somewhat resembling what may be called the tree system, there being switches in each passage, as well as sundry switches in the rooms, which are with few exceptions, of the Lundberg type. The whole of the wires are laid in grooved woodwork, and no wires laid between the floors, or out of sight. Where, however, the mains necessarily pass through the floors and walls, they are wrapped with asbestos, passed through iron pipes to prevent injury from rats or other cause.

The vitrite holders and Edison-Swan collar lamps are used throughout. Fusible cut-outs are provided for the branch wires to every lamp (with few exceptions). There are also numerous cut-outs to the various main branches. In addition to the cut-outs on the distributing switch-board, the mains are protected by a fusible cut-out on the negative cable in the dynamo house, and there also by a magnetic cut out (Cunnyngham's patent) on the positive leads from each dynamo to the dynamo switch-board.

Wentworth Castle being a place of interest, full of valuable paintings and other objects of attraction, some further detailed description of the lighting of the principal rooms may be interesting. Commencing with the east wing, on the upper floor is the picture gallery, extending the whole length of the wing, 176ft. long and 24ft. broad, proportionately high, and is considered to be one of the largest in Yorkshire. The building being of a classical style, the walls are divided by numerous pilasters supporting the architraves which run round, and there are arches near each end resting on white marble. This is lighted entirely with side lights from brackets of light and special design, in appearance resembling the stalks of flowers rising from a group of leaves and drooping over. Leaves of chased brass are placed at intervals on the stem, which terminates in a globular frosted glow lamp specially made for this installation. The effect is heightened by mirrors placed between the pilasters, the lights on either side of these bending gracefully forward so as to be reflected. There are 107 lamps in this room; the appearance of the lights hanging from their graceful stems, either singly, double, or in groups like bunches of fruit, is exceedingly pleasing, if not unique. The pictures are well lighted, and the whole is seen to great advantage. Omitting the remainder of

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the upper rooms, we descend the grand staircase, which is lighted by a 7-lamp electrolier (Fig. 8), and enter the Strafford Room, which is lighted by 8 side lights. The walls of this room are lined with valuable pictures, as, indeed, are all the rooms on the ground floor of the east and south wings. Next follows the dining room, lighted by 12 side lights and also by a pendant electrolier for dining table, &c., containing three groups of lamps under three dome shades, which are capable of sliding backwards and forwards (Fig. 9). The apparatus may be described as consisting of spring brushes travelling in + and − rectangular channels, and connecting with a centre by cone bearings so as to allow of a rocking action in the electrolier when being drawn in one direction or the other. The weight of the electroliers is carried by insulated pullies on an independent travelling line. This makes a most effective and brilliant way of lighting a dining room table. Following on is the grand hall, decorated in white and gold, lighted by 16 side lights. These are for the most part placed in front of mirrors, and on light descending stems proceeding from lions' heads, in keeping with the other decorations. It may be here remarked that the whole of the east wall of this story is decorated with mirrors, which have lights on each side of them. The lower floors of the eastern wing consist of several libraries and sitting rooms, which are lighted with side lights on brackets of varied designs.

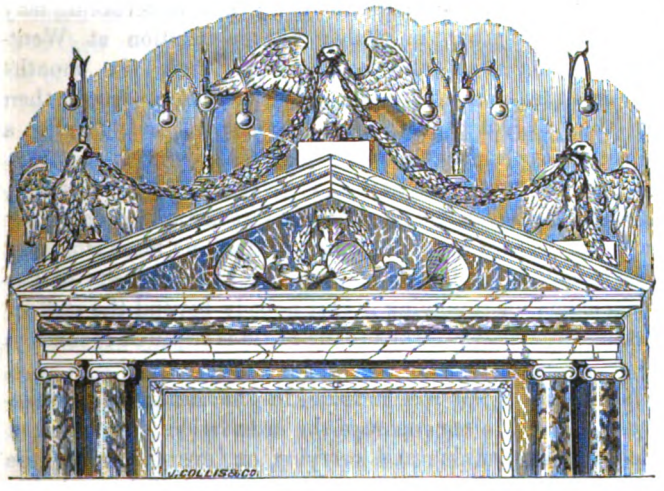

FIG. 7.—Lighting over Mantelpiece in Gallery.

The upper rooms, known as the Swan, Roman, Canopy, and Ark, are lined with tapestry, doors included, which is said to be unsurpassed. These are all lighted by side pendants of various colours, suspended from brackets above the tapestry.

These rooms being also furnished as sitting rooms, there are double jointed brackets on either side of the fireplace for convenience of reading, as there are also in many other rooms. Referring to the other parts of the house it may be remarked that the whole is well lighted, the kitchen, for example, having six pendant lights.

An outside cable is run to the conservatory, which is lighted up for reading and writing, and for lunching, the effect of the light amongst the ferns and flowers, orange trees, and foliage being charming.

There are sundry outside lamps for lighting up the approaches. The outside premises consist of steward's house, stables and coach houses, cow houses, farmyard; also the laundry, dairy, &c., with other appurtenances. To light these a branch cable of Callender's make joins the main cable at about 200 yards from the dynamo station. This leads to a central switch-board, which is of slate—Hartnell's patent—which switches off both the positive and negative wires, with fusible cut-outs on the main leads and on the positive and negative of each circuit. These premises are lighted for the most part by simple pendants, which call for no special remark excepting that the work is thoroughly done, no part being left unlighted. There are 97 lights on this circuit. There are besides 15 lights in the premises adjacent to the dynamo.

The greatest care has been taken not only in the general plan of this arrangement, but in all the details, from the boilers to the lamps, to make it as perfect as possible in every respect, everything being of the best quality. In addition to the special arrangement for the simplification of the switches complete instructions, mounted and framed, are placed near each switch-board; in short, the utmost pains are taken to make the whole most simple and intelligible. The installation has now

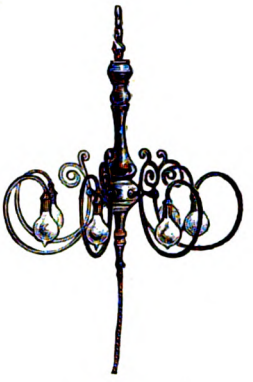

FIG. 8.

run for over nine months without a hitch of any kind, and that, too, without the supervision of any electrician or anybody beyond those already employed on the estate. These facts are of the greatest importance, proving that the electric light can be so arranged as to be perfectly trustworthy, easily and inexpensively managed, and to give no trouble whatever. Its advantages as compared with the paraffin lamps, candles, and lanterns previously used are immense, and with such an example of beauty, brilliance, and elegance it is to be expected that ere long we shall see many of the large and historical mansions similarly lighted, and in this way the owners will secure for themselves the greatest comfort, convenience, and pleasure,

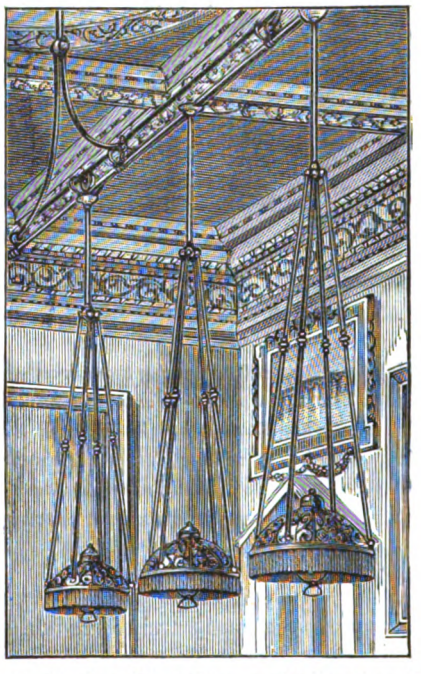

FIG. 9.—Pendant Electrolier over Dining Room Table.

whilst adding to their historic treasures that which is one of the greatest triumphs of the present century.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this Company for the half month ended the 30th September are £1,678, as compared with £1,862 in the corresponding period of 1885. The June receipts, estimated at £5,322, realised £5,333

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, *Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.*

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

VOLUME XVI.

Volume XVI. of "The Electrician," price 10s. 6d., is now ready.

Also cases for binding, price 2s.

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ANSWER TO CORRESPONDENT.

X + Y.—*We do not know of any book containing the description you require. A number of illustrations, with descriptions of Wheatstone's apparatus, as shown at the Crystal Palace Exhibition, will be found in* THE ELECTRICIAN, *Vol. IX. Descriptions will be found in the text books of Preece and Sivewright, and of Culley, both published by Longmans and Co.*

TELEGRAPHIC FRAUDS.

Under this heading we last week published a paragraph with reference to accusations seriously reflecting on the local officials of the Western Union Telegraph Company. Our authority was the (American) *Electrical World*, which again had the statement from an American contemporary. We omitted to give our authority for this piece of gossip, a circumstance rendered the more unfortunate by the accidental insertion of the word "cable" in our description of the "lines." The representative of the Western Union Company on this side of the water—the lessees of the American Cable Company—positively assures us there is no foundation for the statement; and, of course, there never was any as against the "Cable" Company. We gladly accept this assurance, and hasten to express our sincere regret at having inadvertently given pain and annoyance by publishing the paragraph in that misleading form. The wording complained of was, in fact, due to a mere blunder, the writer of the abstract failing to observe that "local officers" might be construed as referring to any person or persons in this country. We give prominence to this explanation, in order that no effort on our part may be spared to correct the erroneous impression which is said to have arisen from our note.

ISOLATED INSTALLATIONS.

We notified in these columns last week that our present issue would contain some fuller information respecting an experiment on a large scale and of considerable importance as touching the question of indoor and domestic lighting by means of electricity. A special agent of *The Electrician* has personally visited the place where this experiment has been carried out, and we are now able to publish a descriptive account of what he saw, illustrated by drawings taken on the spot. We call it an experiment, because in the present state of electric lighting development every new undertaking may be so regarded; but in reality the installation at Wentworth Castle was completed more than six months ago, and has been in constant operation from then until now. Our agent went to inspect not merely a completed work, but a work which had stood the test of a trial as severe as any it is ever likely to be put to, and which has given the most perfect satisfaction to everybody concerned. There has been, we are assured, no hitch whatever in the supply of the light; and such is the simplicity of the arrangements for supplying it that nobody beyond the staff of assistants ordinarily attached to the castle is required to manage or superintend the working.

The reason for this will be found in the admirable arrangements described in our report of the installation. No care had been spared in planning and carrying out every detail of the scheme, with a view, not only to its security and efficiency, but to its being rendered virtually independent of any special technical supervision. The elaborate precautions which have been taken in every direction against accidents of all kinds may appear at first sight, when read in the detailed account furnished by our correspondent, suggestive of constantly recurring danger. But a similar suggestion would arise were we nowadays to describe all the needful devices with which long usage has familiarised us in the case of gas. In describing the particular safeguards adopted at the seat of THOMAS C. F. VERNON WENTWORTH, Esq., our object is to supply information for the guidance of contractors elsewhere; and this we do the more confidently because the results of a good six months' trial justify its being adduced as a pattern of efficiency. Nobody can seriously allege that gas is either safe or sure; but experience has gone a very long way to make it both. Similarly we are aiming at making electricity not less harmless and trustworthy, and it must be confessed that the progress already made is highly encouraging. Indeed, with Wentworth Castle before us lighted throughout from stables to picture galleries, and from kitchen to banquet hall, we feel tempted to say that the plant and appliances are now in such a perfected state that domestic lighting by electricity is certainly as safe as by gas, and in similar situations—that is to say, isolated from any great centre of supply—is almost, if not quite, as sure.

Apart, however, from the purely technical features of this installation, there are points of interest about it which have an

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important bearing on the future of domestic lighting. Its perfect success at Wentworth Castle will be an example soon followed by the owners of other country seats for which England is so justly famous. At very many of these places, as at Wentworth, there are collections of pictures and works of art of priceless value, which it is the honourable obligation of the proprietor to preserve unimpaired. To efficiently light such establishments with oil or candles has been found both difficult and dangerous; and to the manufacture of gas on the premises—which is at best a costly and cumbersome business—there is the still graver objection that its consumption means injury and often complete destruction of the finer specimens of decorative and pictorial art. Add to this the vitiated atmosphere inseparable from the use of gaslight—a fact of which the upper classes are latterly showing their appreciation by reverting to the use of candles or oil—and we have a condition of things highly favourable to the electric light, the manufacture of which is easy and cheap, and its consumption wholesome and cleanly.

As a proof of the acknowledged unfitness of gas for purposes of this kind, we have only to mention the fact that Wentworth Castle is situated within a few hundred yards of coal mines on the estate; and is therefore within reach of coals at their very cheapest. Were cost a sole object, coal gas would of course be employed here, if anywhere; but except as fuel for the engines, the price of coal does not enter the question; and we suspect that this is the case generally elsewhere. The electric light is a luxury, but when it is charged with being an expensive luxury we reply that so, too, was gas in its earlier days, and is so still for the many who can only afford mineral oil. Even in situations where the cost of production is far greater than at Wentworth, the electric light will gladly be paid for as a desirable luxury. It is far less expensive than candles, and involves less trouble than either candles or oil lamps; and, what is of equal moment, it is more ornamental than either, and not so liable to accident. The beauty of the lighting at Wentworth Castle is a matter of general observation, adding as it does to the splendour of the rooms by night, and appropriately displaying those objects of art which previously had been lost to sight with the closing of the day.

One other point worth special notice has been established by this installation, namely, the peculiar mobility of the new light. The lights can be shifted about from place to place, accumulated at particular points when required, or distributed over larger areas at pleasure. Nothing like this can be said for gas lighting on a similar scale. A gas pipe is an unpliable thing, and the gasfitter an uncongenial adjunct to one's establishment. The electric wire is perfectly tractable in comparison, and its fittings are incomparably more accommodating. An example of what we mean may be seen over the table in the dining room of Wentworth Castle, where by a simple mechanical contrivance the positions of the electroliers are expanded so as to suit any length the table underneath may be required to assume. To complete the convenience, switches at suitable points facilitate the instantaneous lighting of a number of lamps in any given direction, and, what is of almost equal convenience, their immediate extinction. Some 400 or 600 lamps are in this way under the perfect control of unskilled attendants, who if they follow their instructions can make no mistakes, and who can do very little mischief even if they are careless. The installation is, on the whole, of so excellent and comprehensive a character that it affords examples of almost every kind of domestic electric lighting, and we heartily commend it to the attention of our readers.

CORRESPONDENCE.

THE ELECTRIC LIGHT AND EYESIGHT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the article on this subject in to day's *Electrician*, based on the paper read by Mr. Oakley before the Sanitary Congress at York last week, you remark that he attributes the prevalence of shortsightedness among the rising generation to "increased pressure of schooling, to the excessive use of the eyes for near objects, and to close application with strong mental effort in early life."

This doubtless is true, but it is not the whole truth, inasmuch as it is the *circumstances* under which the said schooling is conducted, rather than the schooling itself, which tend to produce this shortsightedness. That I am correct will, I am sure, be admitted by any one who will read Prof. Fuchs' Prize Essay on "The Causes and Prevention of Blindness," a translation of which, by Dr. Dudgeon, of London, was published last year by Boillière, Lindall, and Cox. In this book all the causes which lead to blindness and short sight are thoroughly investigated, and the means necessary for their prevention examined.

At page 37, Prof. Fuchs says, with regard to *illumination*, "In his first investigations in 1865 Cohn paid particular attention to this factor. Twenty elementary schools examined by him, in which the requirements of the education were pretty much alike, and therefore admitting of a comparison, showed a variation in the number of myopes of from 1·8 per cent. to 15 per cent., dependent on the illumination of the school rooms." Here, then, is shortsightedness directly attributed to defective illumination. After pointing out the requirements for affording a sufficiency of good daylight, he attends to artificial illumination. He says:—

"For larger schools with evening instruction, especially for drawing lessons, electric light is advisable. The first employment of this, as far as I am aware, was made in the middle and technical schools of Liége, which were opened in October, 1883. Three rooms for drawing classes were lighted by electricity; each room, 13⅓ yards wide and twice that length, was lighted by two electric sun lights. These were fixed at the lower end of iron rods, which hung halfway down into the room. Underneath each sunlight there is a concave mirror, one side of which shades the light from view, while the other throws the light on the white-washed ceiling. From this it is reflected throughout the room. Thus, the light comes from above and falls in pretty equal degree upon all the desks, whilst the sources of the light themselves are invisible. The light is quite sufficient, but not at all dazzling."

He here refers the reader to p. 192, where the conditions of an artificial light are examined in relation to the health of the eyes. He shows that to be wholesome a light should be bright, that it should not be dazzling, that the flame should not flicker, that a light having a minimum of yellowish tinge is that which is best endured, that an artificial light is injurious in proportion to the degree of heat which it produces, and he also dwells upon the atmospheric deterioration caused by petroleum, gas, and colza oil, adding, "the electric light causes no pollution of the air." He sums up the result of his facts as follows:—"From a hygienic standpoint the electric light must be regarded as the best, provided a proper construction of the apparatus shall secure the necessary steadiness of the light, and that when the intensity of the light is great its source shall be concealed from the eye.

"By the electric light the air is neither polluted nor heated. The illumination is so excellent that the acuteness of vision is increased by ⅕ to ½ compared to gas. The acuteness of vision for colours is doubled or quadrupled (Cohn). Where the electric light has been employed on an extensive scale no complaints have been made of straining of the eyes (Javal, Poucet du Cluny, Cohn). I can corroborate this for the Liége Schools."

If it was once fully and generally understood that from the standpoint of health, and especially from that of the health of the eye, and the preservation of sight, how greatly superior the electric light is to every other form of artificial illumination, it surely would not be so very long, after all, before "the electric light will help the ordinary scholar with his books."

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Prof. Fuchs, it must be remembered, is a perfectly independent witness; and as Professor of Ophthalmology in the University of Vienna he speaks with an authority which no one can dispute.—Yours, &c., GILBERT C. POPE.

13, Church-road, Tunbridge Wells, October 1, 1886.

EFFICIENCY TESTS OF DYNAMOS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With reference to your remarks on my letter in last week's issue, I would beg to say that I indicated *two* methods in my letter of March 15th. The one to which you allude depends upon the use of a dynamometric brake, which has the advantage of being much more accurate and easy than a transmission-dynamometer test. As for the other, it must be admitted that mechanical and other friction is independent of the current strength in the armature; but this need to be admitted only for similar working circumstances, the motor being used only as a motor, and the generator only as a generator.

This being admitted, it is clear that the difference in electric work supplied to the motor in two tests (of course, the loss in heating the wires of the motor being taken in account) will be equal to the difference of the mechanical work delivered by the motor.

Thus, the mechanical work consumed under given circumstances by a dynamo-generator may be determined by two tests, one with generator and motor coupled together, and one with the motor alone, but with the same current in the electro, and at the same speed.—Yours, &c.,

C. L. R. E. MENGES.

The Hague, Holland, October 5th, 1886.

THE PROPOSED ELECTRIC LIGHTING AT BOURNEMOUTH.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your note on "The Proposed Electric Lighting at Bournemouth," in your last issue, you state that only incandescent lights upon a low tension current were used, whereas an arc lamp of 3,000 candle-power was running off the same circuit; in fact, it was the same plant which gave such satisfaction at the Inner Temple, on the occasion of the visit of the Princes Louise, on the 19th June last, and was noticed in your esteemed journal. In replying to the question of danger I volunteered to go to the engine room, and in presence of any of the audience would grasp the poles or brushes of the dynamo whilst running, as I had frequently done before. Mr. Donkin, the secretary *pro tem.*, then stated that he also had done so at my request, with the result mentioned. I then appealed to Dr. Philpots, the gentleman who took the chair on two previous occasions, and who has the only electric light installation in Bournemouth up to the present time, and he admitted that on one occasion he happened to touch his electric light leads and was completely knocked over, showing the effect of careless workmanship. The doctor is a very enterprising man, and had already incurred considerable expense in fitting up, and it was a misfortune that the original work was not efficient. I offered to make the installation so that he could use it at cost price, and have received the following letter from him:—

(Copy.)

Dear Mr. Shepherd: Thanks to your skill my installation has become a greater success than it has hitherto been. In fact, it is now perfect with one exception, I must have a larger dynamo. I have quite sufficient faith in your judgment from past experience to be guided by you in your choice of a machine. You know I want one on a good system for 100 lights. If you see one you can recommend please let me know, and we will at once see about the purchasing of it.—Yours sincerely and obliged,

Signed, E. P. Philpots, M.D.

If you will kindly insert this you will greatly oblige.—Yours, &c., JAMES SHEPHERD.

2, Great Queen-street, Lincoln's Inn-fields,
London, W.C., Oct. 6, 1886.

SILENCE IN A TELEPHONE.

When a conductor subjected to alternating currents is divided between two points into two parallel portions, and when the terminals of a telephone are connected, one to a point in one of those parallel portions and the other to a point in the other portion, silence may, under certain circumstances, exist; just as when the split conductor is subject to a uniform current, and a galvanometer is substituted for the telephone, no visible motion of the needle may take place.

In either of these cases the failure to detect an electric flow may arise from want of sufficient sensitiveness in the instrument employed, telephone or galvanometer, or to a want of sufficient sensitiveness in the organ of sense employed, ear or eye.

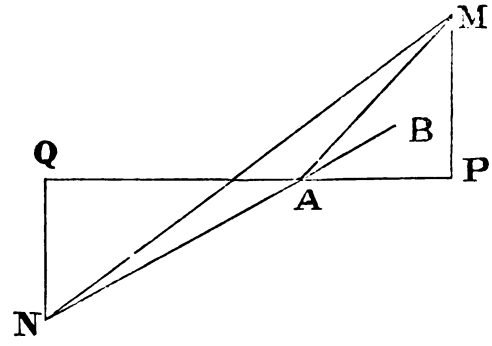
But if in either case no electric flow takes place, then there must be silence in the telephone, and no movement given to the galvanometer needle, however sensitive the instruments, and however quick the senses. Absolute silence in a telephone will therefore exist when its terminals are always kept at equal potentials.

The problem of determining the conditions of absolute silence may be complicated by the existence of coefficients of self-induction in the four portions of the divided part of the conductor, by coefficients of mutual induction, not merely between these four portions, but between them and the rest of the circuit, and by the existence of finite capacity at points of the parallel portions.

I propose merely to deal with the very limited case of the presence of self-induction in each of the four portions of the parallel parts, each section being supposed to be so situated as to suffer and offer no induction from or on any other portion of the system. This case can be easily handled by the geometrical method, and will afford a fair example of its use.

Consider, at first, one of the parallel portions into which the conductor is split, and let r_1 r_2 be the resistances of the two parts into which that portion is divided by the terminal of the telephone; and let L_1 L_2 be the coefficients of self-induction appertaining to each part.

Since there is no current through the telephone, any current through r_1 must exist also through r_2. Hence the currents in these parts must be identical in phase and value. On this account, therefore, the effective electromotive forces through the two parts must be in the same phase, and proportional to the resistances of their respective parts. If, therefore, we take a line P Q, and divide it in A, so that P A : A Q :: r_1 : r_2, P A, A Q may



be taken to represent the effective E.M.F.'s through r_1 and r_2. At the point A set off the angle P A M, so that $\tan PAM = \frac{L_1 \pi}{T r_1}$ where 2T is the period of the alternations.

And at the same point A, but on the side of P Q, remote from M, set off the angle Q A N, so that $\tan QAN = \frac{L_2 \pi}{T r_2}$.

Draw P M, Q N, perpendicular to P Q, meeting A M, A N, in M and N respectively.

Then M A represents the difference of potential of the extremities of r_1.

P M represents the E.M.F. of self-induction in r_1.

A N represents the difference of potential of the extremities of r_2.

N Q represents the E.M.F. of self-induction in r_2.

If M N be joined, M N will represent the difference of

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potential of the remote extremities of the two parts, *i.e.*, the difference of potential of the points between which the circuit is divided into parallel portions.

But this difference of potential exists for the other parallel portion, the resistances of which are r_3, r_4, let us suppose. If we were to construct a similar diagram to the above for the other parallel, we should arrive at another triangle M′ A′ N′, of which we know that M′ N′ will represent the same magnitude as M N.

M′ A′ will represent in phase and magnitude the difference of potential which exists between the second terminal of the telephone, and that end of r_3 which joins on to r_1, which point differs in potential M A from the first terminal of the telephone. If, therefore, the terminals of the telephone are to be always at equal potentials, M′ A′ must be to M A as M′ N′ to M N, and the angle N M A must be equal to the angle N′ M′ A.

The same argument applies to the lines N A, N′ A′. *In fact, the triangles must be similar and the conditions of absolute silence in the telephone are expressed in the same way as the conditions of similarity in the triangles*, translating the elements of the triangles into the physical quantities they represent.

The conditions that two triangles are similar to each other are two in number.

Probably the simplest we can select in this case are—

(1). That $\frac{M A}{N A}$ shall be equal to $\frac{M' A'}{N' A'}$.

(2). That the inclination of M A to N A shall be equal to that of M′ A′ to N′ A′.

Now
$$M A^2 = (P M)^2 + (P A)^2$$
$$\frac{P M}{P A} = \frac{L_1 \pi}{T r_1}$$
$$\therefore M A^2 = P A^2 \left\{ 1 + \left(\frac{L_1 \pi}{T r_1} \right)^2 \right\}$$

Similarly
$$N A^2 = Q A^2 \left\{ 1 + \left(\frac{L_2 \pi}{T r_2} \right)^2 \right\}$$

$$\therefore \frac{M A}{N A} = \frac{r_1}{r_2} \cdot \frac{\left\{ 1 + \left(\frac{L_1 \pi}{T r_1} \right)^2 \right\}^{\frac{1}{2}}}{\left\{ 1 + \left(\frac{L_2 \pi}{T r_2} \right)^2 \right\}^{\frac{1}{2}}}, \text{ since } \frac{P A}{Q A} = \frac{r_1}{r_2}$$

Similarly
$$\frac{M' A'}{N' A'} = \frac{r_3}{r_4} \cdot \frac{\left\{ 1 + \left(\frac{L_3 \pi}{T r_3} \right)^2 \right\}^{\frac{1}{2}}}{\left\{ 1 + \left(\frac{L_4 \pi}{T r_4} \right)^2 \right\}^{\frac{1}{2}}}$$

in which L_3 L_4 are the coefficients of self-induction appertaining to r_3 r_4 respectively.

The first condition, therefore, is that

$$\frac{r_1}{r_2} \cdot \frac{\left\{ 1 + \left(\frac{L_1 \pi}{T r_1} \right)^2 \right\}^{\frac{1}{2}}}{\left\{ 1 + \left(\frac{L_2 \pi}{T r_2} \right)^2 \right\}^{\frac{1}{2}}} = \frac{r_3}{r_4} \cdot \frac{\left\{ 1 + \left(\frac{L_3 \pi}{T r_3} \right)^2 \right\}^{\frac{1}{2}}}{\left\{ 1 + \left(\frac{L_4 \pi}{T r_4} \right)^2 \right\}^{\frac{1}{2}}}$$

or

$$r_1^2 r_4^2 \left\{ 1 + \left(\frac{L_1 \pi}{T r_1} \right)^2 \right\} \left\{ 1 + \left(\frac{L_4 \pi}{T r_4} \right)^2 \right\} = r_2^2 r_3^2 \left\{ 1 + \left(\frac{L_2 \pi}{T r_2} \right)^2 \right\} \left\{ 1 + \left(\frac{L_3 \pi}{T r_3} \right)^2 \right\}. \quad (\alpha)$$

To express the second condition, produce N A towards A to B.

Then the angle B A M is the inclination between M A and A N.

$$\text{Tan B A M} = \tan \{ P A M - Q A N \}$$
$$= \frac{\tan P A M - \tan Q A N}{1 + \tan P A M \tan Q A N}$$
$$= \frac{\frac{L_1 \pi}{T r_1} - \frac{L_2 \pi}{T r_2}}{1 + \frac{L_1 L_2 \pi^2}{r_1 r_2 T^2}}.$$

The corresponding function for the other parallel is

$$\frac{\frac{L_3 \pi}{T r_3} - \frac{L_4 \pi}{T r_4}}{1 + \frac{L_3 L_4 \pi^2}{r_3 r_4 T^2}}$$

Therefore the second condition is that

$$\frac{\frac{L_1 \pi}{T r_1} - \frac{L_2 \pi}{T r_2}}{1 + \frac{L_1 L_2 \pi^2}{r_1 r_2 T^2}} = \frac{\frac{L_3 \pi}{T r_3} - \frac{L_4 \pi}{T r_4}}{1 + \frac{L_3 L_4 \pi^2}{r_3 r_4 T^2}} \quad . \quad . \quad . \quad (\beta).$$

The conditions (α) and (β) are all that are necessary for absolute silence in the telephone *under the circumstances proposed*, but among the circumstances occurs the period of the alternation, and it is quite possible to have (α) and (β) satisfied for one value of T but not for another. Thus the telephone might be silent for one tone but not for others, as tone depends upon period, and (α) and (β) are only the conditions of the silence in regard to a particular note. It remains to be seen whether it be possible to obtain silence for all notes, one independent of the value of T.

From the construction of the figure, it is clear that if T is very large M and N move to P and Q respectively, and M A becomes coincident with P A, and M N with P Q. Therefore, in order that A may divide P Q in the same ratio for both figures, it will be necessary that $r_1 : r_2 = r_3 : r_4$, or $\frac{r_1}{r_2} = \frac{r_3}{r_4}$, the usual bridge condition for no current through the galvanometer.

Now, bearing this necessary relation in mind, and noting that M P and N Q are drawn perpendicular to the same straight line P Q, so that P A : A Q :: r_1 : r_2, it will be impossible that this relation shall hold good for all straight lines drawn through A unless A lies in the straight line joining N and M.

In this case M A N becomes a straight line, making equal angles with P Q.

Hence
$$\frac{L_1 \pi}{r_1 T} = \frac{L_2 \pi}{r_2 T}$$

or
$$\frac{L_1}{L_2} = \frac{r_1}{r_2}$$

and $\frac{L_3}{L_4}$ must follow the same rule, *i.e.*,

$$\frac{L_3}{L_4} = \frac{r_3}{r_4} = \frac{r_1}{r_2} = \frac{L_1}{L_2}.$$

When these conditions are fulfilled the condition (β) is necessarily satisfied, the inclination of the lines M A, A N, being always zero. Hence these conditions are all that are needed to produce silence in the telephone for all periods of alternations harmonically executed.

SOME POINTS IN THE THEORY OF MAGNETISM.

BY FREDERIC A. B. PERRINE, D.SC.

Something over a year ago, while at Princetown College, my attention was drawn to a remarkable series of results published by Prof. John Trowbridge, in *Silliman's Journal*, where he states that when a permanent magnet is cooled to − 20° C. it loses 66 per cent. of its original magnetism. Some doubt being expressed concerning the accuracy of these results, it was determined to institute a series of experiments to test them, which was accordingly done, and resulted not only in a confirmation of his results, but also pointed out the fact that as one cooled a permanent magnet the moment at first increased to a maximum and then decreased, this maximum appearing, with the magnet used, at about − 10° C.

Somewhat similar results have been obtained by M. Favé (*Comptes Rendus* LXXXII., p. 276), but they have not been confirmed by the experiments of Gaugain, Defur, and Wiedemann. The discrepancy seems to me, however, to be explained by the fact that the temperatures used by these latter experimenters were not low enough to reach the maximum,

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consequently they only observed an increase of the magnetic moment on cooling the magnet. My experiments seem to me to point to an incompleteness in the theories of magnetism cited by Wiedemann in *The Electrician* for July 9. Quoting Hughes, he says, (*a*) "Each molecule of a magnetic metal is an unalterable molecular magnet," and there is, further, (*e*) "a rigidity which retains the molecules in their positions after the cessation of the active forces." This "rigidity" is what has commonly been called "coercitive" force of the metal, and depends on the temperature of the magnet. If these two are the only active forces which govern the molecules when once directed along the axis of the bar, the only effect of changes of temperature would be the increase or decrease of the coercitive force, together with a change in the dimensions of the bar. The increase of the magnetic moment on cooling would in this case be due entirely to the increase of the coercitive force, and would rapidly approach a constant value which would never exceed the intensity of the original magnetisation; for, after the coercitive force had become sufficient to retain this amount of magnetism any further increase would be of no effect. Indeed, I cannot see how a reduction of the temperature below that of the original magnetisation would have any effect towards increasing the magnetic moment, for since permanent magnetism is but the residual effect of the magnetising force, the maximum of magnetic moment should be at the temperature where the coercitive force is equal to its value at the time of magnetisation. My experiments clearly show that not only does the magnetic moment continue increasing to a temperature much below that of the original magnetisation, but that it also reaches a maximum, and beyond that point begins to decrease again, and from Prof. Trowbridge's experiments seems to decrease very rapidly till there is a total disappearance of magnetic moment somewhere about the point of the absolute zero.

The true explanation seems to me to rest upon the movements of the molecular vortices of the body. Let us suppose that the vortex atom is impressed by a certain energy—in action analogous to electrical energy—and that the vortex filament of any magnetic body composed of these vortex atoms has a rotational motion about its axis apart from the proper motion of these fluid elements along the vortex lines. This rotation will have two effects, the one tending gyrostatically to keep the filament in a constant plane, the other tending to make the filament act as a magnetic shell by reason of the rotation of the electrical masses in it acting as a current revolving around it.

On this hypothesis the coercitive force will be due to the positions and movements of the vortices and the gyrostatic action of the vortex atoms, and will be independent of the motions or energy in the vortex atoms, while the magnetic action of any filament will depend both on the rotation of the filament about its axis and on the action of the vortex atom itself. The effect of heat on these vortices is to increase the rapidity of their motions, which will increase both their gyrostatic action and the intensity of the current about them, and in consequence their magnetic action; but, at the same time, it must be remembered that these vortices have a motion in space along their axes as well as their vortical motions, which overcomes the effect of the gyrostatic action when one raises the temperature to a high point, and hence the increase in volume and loss of rigidity of the body; at the same time, the actions of the vortical magnetic shells upon each other become very intense, and will finally render insignificant both the directive force of former magnetisations, and also, on account of the law of the inverse squares, any present magnetising force, and forming themselves into closed magnetic circuits will have no external effect. As one cools the magnet from this point the excursions of the vortices in space are lessened in amount, the gyrostatical forces are lessened, and the mutual magnetic actions of the vortices are reduced below that of the external forces upon them; hence, still turning themselves so as to embrace the greatest number of lines of force, their axes will be turned towards a position parallel to the axis of the bar, the component of the external forces diminishing continuously as they approach this position. This will cause the magnetism to approach a maximum, after which point the effect of a further decrease of the temperature will be to diminish the magnetism by diminishing the intensity of the magnetic shells.

In the case of a steel bar permanently magnetised, and brought to a stable condition by heating, or cooling, or jarring, if the heating has not been carried to the point of total loss of magnetism, cooling will, reducing the gyrostatic force of the vortices, allow the magnetic forces to direct their axes parallel to the axis of the bar; the magnetism will increase till the component of the directive force being lessened in amount by reason of the position of the vortices, the decrease in the magnetic intensity will begin to show itself, and having risen to a maximum the moment of the magnet will begin to decrease. The total loss of magnetism would occur at - 273° C., when the motions of the vortices would cease.

This hypothesis calls in a rotational motion of the vortex filaments around their axes, in addition to their regular vortical motions to explain magnetic action. This assumption seems to me to be warranted by the facts—I have lately been struck with its resemblance to Rankine's "Theory of Molecular Vortices"—while not, I think, lying open to the objections offered by Thomson to that theory.

A NEW FORM OF CURRENT WEIGHER.*

BY PROF. JAMES BLYTH.

The object of this paper is to describe a method of absolutely determining the strength of an electric current by measuring in grammes weight the electromagnetic force between two parallel circular circuits, each carrying the same current.

For convenience of calculation the circles have the same radius, and are placed with their planes horizontal.

The construction of the instrument is as follows:—A delicate chemical balance is provided, and the scale-pans replaced by two suspended coils of wire. Each of these is made of a single turn of insulated copper wire (No. 16 about) fixed in a groove round the edge of an annular disc of glass or brass of suitable diameter. The disc is made as thin and light as possible consistently with perfect rigidity. By means of two vertical pillars of brass this annulus is attached to a rigid crossbar of dry wood or vulcanite, in the middle of which is placed a hook for suspending the whole from one end of the balance beam. On each side of the hook, and equally distant from it, two slender rods of brass are screwed into the wooden bar, which support two small platinum cups for holding mercury or dilute acid. The position of these cups is so adjusted that when the whole hangs freely the cups are in line with the terminal knife-edge of the balance beam, and have their edges just slightly above its level. The free ends of the insulated wire surrounding the disc, after being firmly tied together for a considerable length and suitably bent, are soldered to the brass supports of the platinum cups, which thus serve as electrodes by means of which a current may be sent through the suspended coil. A precisely similar coil is suspended from the other end of the balance-beam.

We now come to the arrangement by means of which a current is led through the suspended coils, so as to interfere as little as possible with the sensibility of the balance. This constitutes the essential peculiarity of the instrument, and is effected in the following way:—An insulated copper wire, having its ends tipped with short lengths of platinum, is run along the lower edge of the beam, and is firmly lashed to it by well rosined silk thread. The ends of this wire, bent twice at right angles, are so placed that their platinum tips dip vertically into one of each pair of the platinum cups which are attached to the vertical rods of the suspended coils. From the other cup of each pair proceed two similarly tipped copper wires, which run along the upper edge of the beam, and are also firmly tied to it. These wires, however, only proceed as far as the middle of the beam, where they are bent, first outwards, one on each side of the beam, at right angles to it, and then

* "On a New Form of Current-weigher for the Absolute Determination of the Strength of an Electric Current," being a paper read before the British Association at Birmingham.

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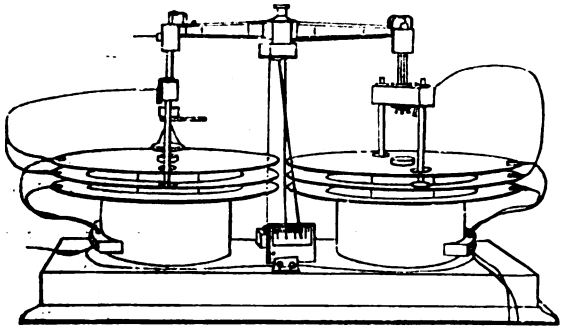
downwards, so that the platinum tips are vertical. The latter dip into two platinum cups attached to two vertical rods, which spring from the base-board of the balance. These rods are placed at equal distances on each side of the beam, and are of such length that the platinum cups are in line with the central knife-edge of the beam, and have their edges just a little above its level. There are thus in all six cups and six dipping wires. Three of these are in line on one side of the beam, and three on the other. Also the line joining the points of each pair of dipping wires is made to coincide with the corresponding knife-edge; and, further, the edges of the cups are all in the same plane when the balance is in equilibrium.

From this it will be obvious that any motion of the beam in the act of weighing causes only a very slight motion of the platinum wires, which dip into the fluid contained in the cups. The resistance due to the viscosity of the fluid is thus very small, even in the case of mercury, and much smaller still when dilute acid is used. In point of fact, the diminution of sensibility due to this cause is less than in the case of determining the specific gravity of solids by weighing in water in the ordinary way, With clean mercury it is quite easy to weigh accurately to a milligramme.



Prof. Blyth's New Form of Current Weigher.

The fixed coils, constituting two pairs, have the same diameter as the suspended coils, and, like them, are made of single turns of insulated wire wound round the edges of circular discs of glass or brass. The discs of each pair are fixed at the requisite distance apart to a cylindrical block of wood, so as to have their planes exactly parallel and their centres in the same straight line. To ensure this they are turned up and finished on the same cylindrical block on which they are finally to rest. When in position they are so placed that, when the balance is in equilibrium, each suspended coil hangs perfectly free to move with its plane horizontal and exactly midway between a pair of fixed coils. For this purpose, as will be seen, it is necessary that two large holes be drilled in the upper disc of each pair, so as to allow the brass pillars of the corresponding annular disc to pass freely through. When the connections are made, the current is led through the entire apparatus in such a way that, while the electromagnetic force acting on the one suspended coil causes it to descend, the electromagnetic force acting upon the other causes it to ascend. The total force tending to disturb the equilibrium of the balance is thus exactly four times that due to an equal current circulating in two parallel circles of the same diameter and with their planes at the same distance apart. The current-strength is estimated from the number of grammes required to restore the balance to exact equilibrium, the weights being placed in small scale-pans attached to the movable part of the apparatus.

The electro-magnetic force between each fixed and the corresponding suspended coil is calculated from the formulæ given by Clerk Maxwell (Vol. II., p. 308), viz. :—

$$\frac{dM}{db} = -2\pi \cos\gamma \left\{ 2F_\gamma - (1+\sec^2\gamma) E_\gamma \right\}$$

where M = the potential energy between two parallel circles, each carrying unit current,

b = distance between their planes,

a = radius of each coil,

$$\sin\gamma = \frac{2a}{\sqrt{4a^2+b^2}},$$

F_γ and E_γ = first and second complete elliptic integrals to modulus $\sin\gamma$.

In one of the instruments constructed

$$a = 10\,8 \text{ inches}, \quad b = \cdot 566 \text{ inches},$$

which give

$$\gamma = 87°, \quad F_\gamma = 4{\cdot}338653976, \quad E_\gamma = 1\,005258587;$$

from which, if G denote the constant of the instrument and $g = 981$, we have

$$G = 4.\frac{dM}{db} \cdot \frac{1}{g} = \cdot 4818.$$

This gives for 1 ampere a force = ·0418 gramme weight.

Besides the one exhibited I have constructed several modifications of the instrument, only one of which, however, needs to be particularly mentioned. In it both the fixed and movable coils are replaced by flat spirals of wire, each of eleven turns. Here the practical construction is more difficult, and the calculation of the constant somewhat more laborious, unless one is content with merely integrating over the area of both the fixed and suspended spirals. This is, I think, however, hardly legitimate, at least with thickish wires, as we thereby suppose that electricity is circulating in the insulating spaces between the wires as well as in the wires themselves. To avoid this I have actually calculated the force exerted by each one of the coils of the fixed spiral upon each coil of the suspended spiral. This entails great labour, as the elliptic integrals have to be calculated for values of the modulus differing very slightly from each other. The labour, however, is worth the taking, as the attractive or repulsive force between two flat spirals is so much greater than that between two simple circles.

Discussion.

Lord Rayleigh said the diagram and description of Prof. Blyth's instrument reminded him of the work upon which he had been engaged for the past two years. The great difference between Prof. Blyth's arrangements and those he had adopted was in the use of mercury connections instead of flexible wire. Perhaps for the scale on which Prof. Blyth was working (apparently with very large currents), the mercury connections acted very well. When he was engaged in designing his experiments it so happened that he tried something, roughly, of this kind; he tried the principle of making the connection with a mercury cup, the point where the wire dipped into the mercury being in the axis of rotation. Perhaps, in consequence of imperfect arrangements, it did not result to his satisfaction, and he concluded eventually to use the flexible connection, which seemed to him really not to contain the objections which at first appeared to attach to it. Of course connection with a flexible wire could not be made without imposing a certain force upon the suspended parts. But the real question was, is that force one which can be depended upon and be eliminated from the experiments? It seemed to him it could be, because although a flexible wire undoubtedly exercised a force, still, when the suspended wires were brought into a perfectly definite position, that force must be very nearly constant, depending, of course, upon the elasticity of the material; and although it was quite true that during the passage of the electric current, and the consequent slight heating of the flexible connectors, the mechanical force exerted upon them by the suspended parts was a little different from that exerted when the apparatus was at rest, still, all those observations could be taken by reversal of the current in the fixed parts of the apparatus, reversing, of course, all the forces operated. Therefore the difference of weight required to obtain equilibrium when the current was reversed in the fixed part of the apparatus gave double attraction, independently of the different force, whether mechanical or electrical, which might be exerted by the connecting wires leading the current into the suspended parts. He must say he found no reason to disapprove of results obtained in that way, but possibly with the larger currents which Prof. Blyth wished to use there might be greater difficulty in managing leading wires of that kind. The current with which he (Lord Rayleigh) had actually worked was about from one-third to one-half of an ampere, and certainly no difficulty arose with that, nor did he think any serious difficulty would have arisen if he had wished to multiply that current a few times. He would like to know whether Prof. Blyth had translated his results into terms of the silver deposited or into the E.M.F. of some standard battery. Without that his absolute results could not be compared with those obtained by previous observers. With reference to the formula quoted from Clerk-Maxwell, it might perhaps be worth while to mention that he had calculated a table giving the quantity required from time to time by $\frac{dM}{db}$ directly, therefore not requiring a reference to the original Legendre tables; and this Prof. Blyth might find useful. As to the point raised with reference to the calculation of the perfect integration of the effect of flat spirals, of course if the two flat spirals were very close to one another it might be a little precarious to assume that the mean effect was the same as if the current were continuous over the whole area. He was not sure that the calculation Prof. Blyth had mentioned met the case much better, because such a calculation seemed to assume that the

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current which, of course, was distributed throughout the section of each wire, was concentrated at its centre; and was that any better than the integration? He could not say at that moment how that might be, but it did not strike him that the objection to the one process was much less than to the other. He was very glad to see that Prof. Blyth had succeeded in designing so convenient an instrument for the absolute measurement of current. That was a very important matter, which perhaps scarcely received the full amount of attention it deserved. A very great deal of attention had been given to the determination of electrical resistance, and many skilful workers in different parts of the world had devoted themselves to the subject. To him it seemed that the measurement of current was at least as important, even if it were not more important, but for some reason or other it attracted much less attention. He hoped Prof. Blyth would continue to work upon the subject, and that he would give his results in terms of the deposition of silver or the E.M.F. of a galvanic battery.

Prof. BLYTH said he had not tested the instrument directly with regard to the deposition of silver, but had compared it with an instrument which he believed was very accurate, one of Sir William Thomson's current meters, and the result he got agreed very well with the currents as determined by that instrument. With regard to the calculation he was sorry to find on referring to Lord Rayleigh's table that it stopped at 70. If it were extended to 87 it would be a great improvement.

Mr. BOTTOMLEY said they had been working very incessantly at Glasgow on the subject of instruments of this class, and he thought they had come to a conclusion which was quite confirmed by what Lord Rayleigh had just said with regard to flexible *versus* mercury connections. They found, after a vast number of trials with all sorts of instruments, more uncertainty with the mercury connections, in consequence of the oxide which formed on the sides, than with the flexible connections, and Sir William Thomson had applied the principle of flexible connections in the form of zig-zag wire made of several, perhaps ten, small wires put together, and in these instruments they were having considerable success as against mercury cups.

Prof. ARMSTRONG said he would like to know whether any one present had made any experiments with a pretty series of flexible connections proposed by Joule. Perhaps in addition to that a series of torsional and flexible suspensions might be employed for the balance so as to avoid knife edges. But then the whole weight of the balance would have to be supported by the wires, and in that case the wires must necessarily be of great strength. These torsional and flexible connections should be so made that there should be no total torsion on the wire, the torsion on the one part compensating for the torsion on the other. He would like to extract from Lord Rayleigh, if possible, his opinion of the relative delicacy, or chances of delicacy, of this method of measuring currents and the silver voltameter method. The latter was so simple, compared with Prof. Blyth's expensive apparatus, that it was of considerable importance that people interested in physical laboratories should know whether it was worth while to get standard instruments of this kind, or whether they should content themselves with merely putting up a silver voltameter.

Prof. GEORGE FORBES would be glad if Lord Rayleigh would give his opinion also as to the Clark cell. People were abolishing every sort of standard instrument except the Clark cell, and they would all like to know what Lord Rayleigh thought was the comparative accuracy attainable with instruments of the kind just described compared with that cell also. One of the chief reasons why people had not been devoting the time and attention to current measurement that they did to resistance was owing to Lord Rayleigh himself. The general opinion was that he had taken the subject so thoroughly in hand and made it so entirely his own, that he had studied it with such very great precision in his experiments, that they might be quite contented to leave it in his hands. He specially asked the question as to the accuracy which Lord Rayleigh would expect from the system under discussion, because he could not think it was comparable in any degree in accuracy as an absolute standard with the employment of a Clark cell. He had made some experiments in the same direction himself, but he had given up altogether the idea of using the method as a standard of current, and employed such an apparatus simply as a current measurer without any magnetism in it. He was inclined to think that that was the chief use of such an apparatus. It seemed to him that there were very great difficulties in the way of making it a very exact thing. Prof. Blyth spoke of comparing his instrument with one of Sir William Thomson's accurate current meters. He did not know which instrument was spoken of, but he did not think any one of those which could have been referred to was comparable with Clark's cell for accuracy.

Lord RAYLEIGH said he did not know whether he understood clearly from Prof. Blyth whether his instrument was intended primarily for the absolute measurement of current or for continuous and daily use, for he regarded those two things as distinct. Prof. Forbes seemed to have interpreted him to mean that he used an instrument of this kind in daily use for determining currents which might occur at any moment. Clark's cell was of enormously greater value for such a purpose as that. The silver voltameter did not measure the electric current unless a certain constant were assumed. The question was whether that constant was known accurately enough. Practically, an absolute measurement of current meant the determination of the constant of the electro-chemical equivalent of silver or the E.M.F. of some galvanic cell. As regarded his own work, he endeavoured to express the results in the terms of both. If he wanted to measure a current at any moment he should use Clark's cell, and if doubtful of the result would then get it by the silver voltameter. All that came to this, that you wished to know whether what you called an ampere was an ampere. The use of the tangent galvanometer involved a knowledge of the earth's horizontal magnetic force, and that was difficult of determination. You might afterwards use your knowledge of that constant as you used your knowledge of the E.M.F. of Clark's cell. It seemed to him that the determination of the constant H was as difficult as the measurement of the current itself, if you wanted an accuracy of 1 in 1,000. If the value of H was known the comparison with the tangent galvanometer was a comparatively simple operation. If an accuracy of ½ per cent. were desired, it would be far easier to measure roughly the value of the earth's horizontal magnetism, and refer the currents to that. Even then he would prefer the silver voltameter.

Mr. R. T. GLAZEBROOK, M.A., F.R.S., said that in measuring currents with the silver voltameter it was necessary to know that the current did not vary greatly during the experiment, which must last for some time, and for that reason the method with the Clark's cell was superior for most purposes.

Lord RAYLEIGH said it was a great merit of the Clark cell, that it would measure the current at any moment. The necessity of instantaneous measurement entirely precluded the use of the voltameter for the measurement of certain currents.

Mr. BOTTOMLEY would like to know what currents Prof. Blyth intended his instrument to measure. The currents required to be measured for electric lighting purposes were very large currents in comparison with anything he supposed his instrument was intended to measure.

Prof. BLYTH said the currents he had sent through the instrument varied from one ampere to ten amperes. He had used nothing higher than from ten to fifteen amperes. The real object of his design was to try by that method to find out if the calculation he had made agreed pretty well with the currents as determined by other means. No doubt the electro-chemical equivalent of silver was so perfectly determined now that perhaps determination by a battery was as accurate a method as any. But he had thought it worth while to try the experiment to see how nearly the calculation agreed with the current as got from the instrument, and what he was especially testing was not so much mercury connections as liquid connections by means either of dilute acid or any other liquid.

AMERICAN FIRE OFFICE RULES.

The following are the rules adopted by the "Boston Tariff Association" for the running of incandescent lamps upon arc light circuits:—

Only such wire as has been approved by this "Union" shall be used in constructing lines and circuits. Wires must be run in plain sight. In damp places they must have a waterproof covering. The positive wire or wires must be kept at least three inches from the negative wire or wires in running from the distributor or regulator to the fixtures and lamps and return, except that "twin wire" may be used for a single lamp. No wires should be run through partitions, floors, or walls without being encased in a tube of hard rubber, porcelain, or if soft rubber is used it must be covered with tape. The "safety fuses" must be so proportioned that they will melt long before the wire is heated to an unsafe degree. Dust must not be allowed in the distributor-box or any of the electrical connections. The contact points should be kept clean, and care should be taken to ensure solid electrical connections at all the points of contact, and all parts must be kept free to move easily. In case any defect should arise in the distributor or regulator, or the wiring thereto, it must be arranged so as to automatically and absolutely shunt off from the arc circuit at once. In working distributors the line of circuit current must be kept at its standard amount by tests made by ampere-meter from time to time. In no case must the amount exceed the standard. Every company shall have a competent and reliable person to examine daily every distributor and regulator, or similar device, which may in the future be applied to arc circuits. The running of incandescent lights or systems on arc circuits should be avoided; but wherever this is unavoidable, a proper device or "distributor," such as may be approved by this "Union," must be provided to prevent the possibility of an excessive arc current being thrown on to any one portion of the incandescent system. Such device or "distributor" must have the approval of this "Union" before it is put in operation; it must remain open to inspection at all times, and no change be made in any part of the installation after it has been approved, without consent of this "Union." Where incandescent lights are run on arc circuits the following named practices are strictly prohibited:—Fastening or attaching electroliers or lamps to any gas fixtures which may be in electrical connection with the earth. The running of concealed wires to the electroliers or lamps under any circumstances; they must be entirely open to view. The placing of any distributor-box or regulator, electrolier, bracket, or lamp in such position that it may be connected in any way with any other wires, steam fittings, gas pipes, gas fixtures, &c., which may be electrically

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connected with the earth. The placing of the distributor, electrolier, &c., in any damp location, or in any close proximity to any metal or other conductor of electricity. The building or placing of anything around the distributor or regulator so as to cut off easy access to it, or obstruct the access of air to it. All joints after leaving the distributor or regulator must be soldered, using acid as flux. Resin will not be approved under any circumstances. All new devices should be submitted to the inspector of the "Union," and must be approved by him before permission can be given for their use.

THE NATIONAL ELECTRIC LIGHT ASSOCIATION OF THE UNITED STATES.

(Continued from page 435.)

We continue from last week the substance of the debate on Mr. Martin's paper upon "Incandescent Lighting and Wiring." Some of the ideas brought out will be found to differ very considerably from English practice :—

Mr. WEEKS: Do you furnish the wire and fixtures, or charge that to the patrons?

Mr. RHODES: That is a question that has come up several times—what to do with fixtures. We have not yet arrived at any conclusion. I think the one we will arrive at will be to insist on having everything done well, and, if necessary, to put in our own fixtures. We will put in such for you at our own expense, doing the entire work and paying for it ourselves, not charging the customers either for the wiring or for the glass globes and shades in connection. This point of charging for fixtures has become a serious one in cities where there is a good deal of competition, and in order to get the business one company and then the other will make sacrifices, and hence the companies have come to do all the work themselves without any charge to their customers. Of course where there is only one company, and that has all the business it can get, it can make the charge against the customers what it pleases. In small towns like our own, where it is necessary in order to get a large amount of business to make some sacrifice, it comes to be nearly a necessity to do the thing yourself. That is a matter to be judged of in each community separately. We believe that in the way we propose to adopt we can get our wiring done more satisfactorily to ourselves, and that we can obtain a sufficient additional number of customers to make it profitable to ourselves. We have had quite a little trouble from poor wiring and from hanging incandescent lights with poor fixtures. We find that it will pay us to furnish proper fixtures, even if they are combination fixtures, having them well insulated and the incandescents properly attached.

Mr. RIDLON: For how long a time do you make a contract with your customers?

Mr. RHODES: For a year. But we have come to the conclusion that whether a customer signs a contract or not it is rather immaterial, because if we have a customer who is dissatisfied with his lamp from any reason whatever, it is much better for us, if such a case should happen, or for any other company, to take the light out immediately and release the man from his contract than to insist upon his using the light against his will until the close of the time. It is better for the company to see in the first place whether the man will continue; and if he is not likely to continue, it is best not to put in the lamp at all.

Dr. GARRATT said he did not believe that with any system of light, whether electricity, gas, kerosene or candles, the party supplying the light should be called upon to furnish the fixtures too. Any man wishful to have the light was willing, he thought, to pay for wiring and fitting up the house. It was thus with gas, and he did not see why an electric lighting company should not be similarly disposed.

Mr. DUNCAN wanted to know who stood the breakage of the lamps.

Mr. RHODES: The company, I suppose, in all cases furnishes the incandescent lamps when breakage happens. Certainly our company does.

Mr. DE CAMP: On the question as to who should repair the lamp. If they charged the customer with half the breakage, that seemed to be equitable. He thought that a company with a number of these lights on an extended system and entirely responsible for the breakage could not afford to neglect them, and that the attendance on them to the extent of inspection would be very nearly equal to that on the arc light. If, however, the parties using these lights knew that when broken the lights were to be replaced at their expense, they would undoubtedly take better care of the property than if the case were reversed.

Mr. GILBERT said that in New England they had been running 125 candle-power lamps on the arc circuit for about three months. They now found they could use them in multiple series without the box, and could certainly get three of them for less than a box would cost. They made their estimates as to the necessary life of lamps, and as to the price that should make them willing to displace the arc. If the lamp lived 400 hours they were going to put in more. For some of them the average time now is 500 hours. They were getting a great deal longer life than they estimated. If the lamps lived 100 hours, they would still get their money back, but not make any profit. He found there was a field for the large incandescent lights just below where the arc lights stop, with people who felt they could not afford the arc light, and they could put in ten of them where they put in one arc light in the dull season. Their insurance inspector was satisfied with them. With the guarantee of the inspector and the experience they had they were going to increase their commercial business much more than with the arc system.

The following paper was also read :—

ON THE TRANSMISSION OF POWER TO THE DYNAMO.

BY JAMES A. PENTZ.

The first essential in the employment of power is to get it transferred to the dynamo by means of, and through, the least number of organs of transmission; and it is likewise important to do it mechanically, in the most direct manner. This brings us face to face with the high-speed engine, and the one-belt method of power transmission from the engine pulley to the pulley of the dynamo as the simplest and the best. Countershafts as applied to electric lighting are quite unnecessary. They require more space than is usually allotted to the driving plant, adding also to its first cost and to the cost of keeping them in good working order. Any increase in shafting and pulleys must require additional attention, and furthermore, additional power to drive them, thereby lessening the effective force of the engine. A few tests of shafts are given herewith, to reinforce the general statement just made:—Fifty-five carefully made experiments, on factory engines, developing under full load from 26 horse-power to 1,485 horse-power, showed the percentum of the extremes of resistance of engines and shafting to full load to be from 16·5 per cent. to 39·2 per cent. of the horse-power, and an average of 25·9 per cent. of the horse-power, while that of the engine alone averaged but 7 per cent. In another series of eight tests of factory engines, the average proved to be 22 per cent., and in another case, where the total horse-power employed was but 120, the resistance amounted to 33 per cent.

If, then, all these drawbacks are to be found in counter-shafting, it should be dispensed with, and some good plan produced whereby electric light plants may be run more economically. No doubt plants run by low speed engines driving to a countershaft have given good results, but if we can do better without this useless auxiliary had we not better do so? It brings us not only to the discussion of the benefits to be derived by belting direct from the engine pulley to the dynamo pulley, but to the superiority of the high speed engine in connection with electric lighting. In the employment of this type of engine we gain these points:—I. Economy of fuel and space occupied by the plant. II. Economy in first cost of the plant. III. Uniformity of speed and regulation. IV. Reduction of cost of repairs and maintenance. Engines of this type must be of the best material and workmanship to insure good running and long life, and should be of ample weight. There should be not the slightest deflection or tremor in the bed under the most trying conditions consequent upon the greatest variation in the load. The revolving parts must be correctly balanced, the reciprocating parts light and strong, the bearings of proper materials and of ample size, the lubrication automatic, and the parts containing steam should be well clothed to prevent loss by radiation. The steam in these engines is utilised in the cylinder to much better advantage than in the cylinders of engines running at low speed, and for obvious reasons.

It is a well-known fact that steam must be used as quickly as possible after it is generated, to avoid loss of efficiency by condensation and radiation of the heat, which is very rapid from the pipes and vessels containing it, as they are usually made and employed. In the early use of steam in running engines, which were necessarily of slow speed, steam jackets were found absolutely indispensable to the proper action of the engine, but later practice with moderately-speeded engines has shown the warming of steam cylinders by jackets to be unnecessary. The modern high-speed engine uses the steam as quickly as possible after it is generated, reducing the time of its transmission to the engine to the least, by which the loss of heat is reduced to a minimum. The saving from this source alone is considerable, and as the steam cylinders of high-speed engines are small in proportion to their power, the losses by reduction of cooling surfaces become smaller also. The economy of fuel as bearing directly upon the engine may be said to begin at this point, and is carried higher by the nearer approach to perfect regulation given by the engine. The action of the governor of the high-speed engine being quicker, the steam is controlled more easily, and the speed of the engine more readily kept uniform. It has been stated that the friction of the engine is increased when it is run at high speed, but recent experiments made at Cornell University, under directions of Prof. Thurston, and with a modern high-speed engine, clearly demonstrated that such is not the case, and, indeed, such a result would be contrary to accepted mechanical theories.

We now come to the most efficient, economical, and decidedly the most satisfactory method of dealing with this question, that of belting direct from the driving pulley of the engines to the dynamo pulley. By this means the connection between the engine and dynamo is single and direct. With the best of dynamos, when driven by engines well adapted to the purpose, good belting is necessary to the securing of uniform results. Belts for driving dynamos should, therefore, be made of the best material, of uniform thickness and density, and practically straight in their run through the air and over the pulleys. They should be soft and pliable and kept so by proper application of the usual and obtainable unguents prepared for this purpose. In the use of belts for driving dynamos, they should be made endless—that is, without unevenly made joints—and when made of double thickness, care should be taken to select such makes as will give an even and full contact surface of the leather constantly to the faces of the pulleys. The best form of engine to drive one or two dynamos is that in which the steam acts upon a centre crank, with ample shaft bearings on each side, and with the pulleys on overhanging shaft ends. From each of these pulleys a belt is run to the dynamo pulley. Either belt may be removed by hand when one dynamo only is required.

Where the number of dynamos required is more than two, the simplest method of belting direct to the dynamos is to use two engines, made right and left, set parallel with each other, and with the main shaft connected to, and running in line, with both engine shafts, supported by proper intermediate bearings from the floor. This practically makes it the same

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as if the engine shafts were extended, and is usually of the same diameter. This being practically inflexible, and running at the same speed as the engine, makes it an easy matter to belt from the pulleys which it supports to the pulleys of the dynamos, thereby delivering the power, with least loss to the electric machinery, direct. Each pulley on this shaft can be made independent, running by a friction clutch, so that, if by any reason a certain dynamo is not required to be run, it can be stopped, and without interfering with the working of the others. At either end of the engine shaft, and directly next to the engines, a cut-off friction coupling should be provided. This is to insure against stoppage of the whole plant, if accident should occur to either engine. By this means one engine can continue to do the work.

Without extending these remarks too far, it is proper to add that numerous experiments have proved that better engineering expedients lie within the limits of the larger diameters for shafting, which secures rigidity from the known fact that the flexibility of the smaller shafts usually employed on the score of economy creates more friction by being drawn "out of line" by the pull of the belts in action upon the dynamo. Again, with regard to the question of perfect regulation of engines, a single engine running at a slow speed will not produce, relatively, as equable a motion as a single engine running at a high speed. To effect regular motion with slow running engines, it is necessary to employ them in pairs, with their cranks set at right angles. Even then the results attained will be no more satisfactory than that effected by a high-speed single engine. There is a normal speed for every build of engine. It is very certain that an engine made for low speed will not run at a high speed without injury to itself, and possible destruction; but we have abundant testimony proving high speed in engine work to be a pronounced success. It involves, of course, many of the less-known elements of design and construction, and ever and always the best of materials, workmanship, and attendance; all of which, however, are within the reach of modern shop practice, as they are of moderate price. If proper care be taken in the selection of steam motors after intelligent examination of such as are already in use; if particular attention be given also to the installation and management of the whole plant; and if no part or parcel thereof be accepted, believing it to be cheapest in the end, because its first cost is least, then will the production of electricity for lighting and other purposes make great and permanent advances.

CHEMISTRY AS A SCIENCE.

(Concluded from page 438.)

I have said that the original *protyle* contained within itself the potentiality of all possible atomic weights. It may well be questioned whether there is an absolute uniformity in the mass of every ultimate atom of the same chemical element. Probably our atomic weights merely represent a mean value around which the actual atomic weights of the atoms vary within certain narrow limits.

Each well-defined element represents a platform of stability connected by ladders of unstable bodies. In the first accreting together of the primitive stuff the smallest atoms would form, then these would join together to form larger groups, the gulf across from one stage to another would be gradually bridged over, and the stable element appropriate to that stage would absorb, as it were, the unstable rungs of the ladder which led up to it. I conceive, therefore, that when we say the atomic weight of, for instance, calcium is 40, we really express the fact that, while the majority of calcium atoms have an actual atomic weight of 40, there are not a few which are represented by 39 or 41, a less number by 38 or 42, and so on. We are here reminded of Newton's "old worn particles."

Is it not possible, or even feasible, that these heavier and lighter atoms may have been in some cases subsequently sorted out by a process resembling chemical fractionation? This sorting out may have taken place in part while atomic matter was condensing from the primal state of intense ignition, but also it may have been partly effected in geological ages by successive solutions and reprecipitations of the various earths.

This may seem an audacious speculation, but I do not think it is beyond the power of chemistry to test its feasibility. An investigation on which I have been occupied for several years has yielded results which to me appear apposite to the question, and I therefore beg permission here to allude briefly to some of the results, reserving details to a subsequent communication to the section.

My work has been with the earths present in samarskite and gadolinite, separating them by systematic fractionation. Chemical fractionation, on which I hope to say more on another occasion, is very similar to the formation of a spectrum with a wide slit and a succession of shallow prisms. The centre portion remains unchanged for a long time, and the only approach to purity at first is at the two ends, while a considerable series of operations is needed to produce an appreciable change in the centre. The groups of didymium and yttrium earths are those which have chiefly occupied my attention. On comparing these rare earths we are at once struck with the close mutual similarity, verging almost into identity, of the members of the same group.

The phosphorescent spectra of these earths when their anhydrous sulphates are submitted to the induction discharge *in vacuo* are extremely complicated, and change in their details in a puzzling manner. For many years I have been persistently groping on in almost hopeless endeavour to get a clue to the meaning I felt convinced was locked up in these systems of bands and lines. It was impossible to divest myself of the conviction that I was looking at a series of autograph inscriptions from the molecular world, evidently of intense interest, but written in a strange and baffling tongue. All attempts to decipher the mysterious signs were, however, for a long time fruitless. I required a Rosetta stone.

Down to a date comparatively recent nothing was more firmly fixed in my mind than the notion that yttria was the oxide of a simple body, and that its phosphorescent spectrum gave a definite system of coloured bands. Broadly speaking, there is a deep red band, a red band, a very luminous citron-coloured band, a pair of greenish blue bands, and a blue band. It is true these bands varied slightly in the relative intensities and in sharpness with almost every sample of yttria I examined; but the general character of the spectrum remained unchanged, and I had got into the way of looking upon this spectrum as characteristic of yttria, all the bands being visible when the earth was present in quantity, whilst only the strongest band of all—the citron band—was visible when traces, such as millionths, were present. But that the whole system of bands spelled yttria, and nothing but yttria, I was firmly convinced. During the latter fractionations of the yttria earths, and the continued observations of their spectra, certain suspicions which had troubled me for some time assumed consistent form. The bands which hitherto I had thought belonged to yttria began to vary in intensity among themselves, and continued fractionation increased the differences first observed. Whilst I was in this state of doubt and uncertainty, and only beginning to see my way towards arranging into a consistent whole the facts daily coming to light, help came from an unexpected quarter. M. de Marignac, with whom I had been for some time in correspondence, kindly sent me a small specimen of the earth which he had discovered and provisionally named Yα (now Gadolinia). In the radiant-matter tube this earth gave a bright spectrum, like the one in the diagram before you. The spectrum above it is that ascribed to yttria. Look at the two. Omitting minor details, Yα is yttria with the chief characteristic band—the citron band—left out, and with the double green band of samaria added to it. Now look at this diagram, which represents the spectrum of a mixture of sixty-one parts of yttria and thirty-nine parts of samaria. It is identical almost to its minutest detail with the spectrum of Yα, with this not unimportant difference—the citron band is as prominent as any other line. Yα consists, therefore, of samaria with the greenish blue of yttria and some of the other yttria bands added to it.

I may aptly call the Yα spectrum my Rosetta stone. It threw a flood of light on all the obscurities and contradictions I had found so plentiful, and showed me that a much wider law than the one I had been working upon was the true law governing the occurrence of these obscure phenomena. For what does the spectrum of Yα show? It proves that what I had hitherto thought was one of the chief bands in the yttria spectrum—the citron band—could be entirely removed, whilst another characteristic group—the double green of yttria—could also be separated from the citron.

It would exceed legitimate limits were I to enter into details respecting the chemical and physical reasons which led me to these definite conclusions. To settle one single point more than 2,000 fractionations have been performed.

The meaning of the strongly marked symbolic lines had first to be ascertained. For a long time I had to be content with roughly translating one group of coloured symbols as "yttrium" and another group as "samarium," disregarding the fainter lines, shadows, and wings frequently common to both. Constant practice in the decipherment has now given me fuller insight into what I may call the grammar of these hieroglyphic inscriptions. Every line and shadow of a line, each faint wing attached to a strong band, and every variation in intensity of the shadows and wings among themselves, now has a definite meaning which can be translated into the common symbolism of chemistry.

In a mineral containing the rarer earths those most widely separated in chemical properties are most easily obtained in a state of comparative purity by simple chemical means. For instance, in separating didymium from lanthanum, or samarium from yttrium, a few simple chemical reactions and a little waste will give these bodies in a state of purity; but when it comes to splitting up yttrium into its components ordinary chemical separation is useless, and fractionation must be pushed to the utmost limit, many thousand operations and enormous waste of material being necessary to effect even a partial separation.

Returning, therefore, after this explanatory digression, to the idea of heavy and light atoms, we see how well this hypothesis accords with the new facts here brought to light. From every chemical point of view the stable molecular group, yttrium, behaves as an element. Excessive and systematic fractionation has acted the part of a chemical "sorting Demon," distributing the atoms of yttrium into several groups, with certainly different phosphorescent spectra and presumably different atomic weights, though all these groups behave alike from the usual chemical point of view. Here, then, is one of the elements the spectrum of which does not emanate equally from all its atoms, but some atoms furnish some, other atoms others, of the lines and bands of the compound spectrum of the element. And as this is the case with one element, it is probably so in a greater or less degree with all. Hence the atoms of this element differ probably in weight, certainly in the internal motions they undergo.

Another important inference which may be drawn from the facts is that the atoms of which yttrium consists, though differing, do not differ continuously, but *per saltum*. We have evidence of this in the fact that the spectroscopic bands characteristic of each group are distinct from those of the other groups, and do not pass gradually into them. We must accordingly expect, in the present state of science, that this is probably the case with the other elements. And the atoms of a chemical element being known to differ in one respect may differ in other respects, and presumably do somewhat differ in mass.

Restricted by limited time and means, even a partial separation of these atomic groupings is possible to me only with enormous difficulty. Have we any evidence that Nature has effected such a separation? The following facts I think supply this evidence.

The earth yttria occurs in several minerals, all extremely rare. These minerals are of a very diverse chemical composition, and occur in

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localities widely separated geographically. Does the pure yttria (*pure* in respect to every other known element) from these different sources behave differently to the radiant-matter test? To the chemist hitherto the earth yttria has been the same thing and has possessed the same properties, whatever its source; but armed with this new power of seeing into the atomic groupings which go to make up yttrium, we find evidence of differentation between one yttrium and another.

Thus, when the samarskite yttrium was formed all the constituent atoms—deep red, red, orange, citron, greenish blue, and blue*—condensed together in fair proportion, the deep red being faintest. In gandolinite yttrium the citron and greenish blue constituents are plentiful, the red is very deficient, the orange is absent, and the others occur in moderate quantities. In the yttrium from xenotime the citron is most plentiful, the greenish blue occurs in smaller proportion, the red is all but absent, and the orange is quite absent. Yttrium from monazite contains the greenish blue and citron, with a fair proportion of the other constituents; the greenish blue is plentiful, and the red is good. Yttrium from fluocerite is very similar to that from monazite, but the blue is weaker. Yttrium from hielmite is very rich in citron, has a fair quantity of blue and greenish blue, less of red, no orange, and only a very faint trace of deep red. Yttria from euxenite is almost identical with that from hielmite. Yttria from cerite contains most red and citron, less greenish blue and blue, only a trace of deep red, and no orange.

This is unlikely to be an isolated case. The principle is very probably of general application to all the elements. In some, possibly in all elements, the whole spectrum does not emanate from all its atoms, but different spectral rays may come from different atoms, and in the spectrum as we see it all these partial spectra are present together. This being interpreted means that there are definite differences in the internal motions which go on in the several groups of which the atoms of a chemical element consist. For example, we must now be prepared for some such events as that the seven series of bands in the absorption-spectrum of iodine may prove not all to emanate from every molecule, but that some of these molecules emit some of these series, others others, and in the jumble of all these kinds of molecules, to which is given the name of "iodine vapour," the whole seven series are contributors.

To me it appears the theory I here venture to formulate, taken in conjunction with the diagram in Fig. 1 (see *ante*, p. 437), may aid the scientific imagination to proceed a step or two further in the order of elemental evolution. In the undulating curve may be seen the action of two forces, one acting in the direction of the vertical line, and the other pulsating backwards and forwards like a pendulum. Assume the vertical line to represent temperature slowly sinking through an unknown number of degrees, from the dissociation point of the first formed element down to the dissociation point of those last shown on the scale. But what form of energy is represented by the oscillating line? Swinging to and fro like a mighty pendulum to points equi-distant from a neutral centre; the divergence from neutrality conferring atomicity of one, two, three, and four degrees as the distance from the centre is one, two, three, or four divisions; and the approach to, or retreat from the neutral line deciding the electro-negative or electro-positive character of the element—all on the retreating half of the swing being positive, and all on the approaching half negative—this oscillating force must be intimately connected with the imponderable matter, essence, or source of energy we call electricity.

Let us examine this a little more closely. Let us start at the moment when the first element came into existence. Before this time matter, as we know it, was not. It is equally impossible to conceive of matter without energy, as of energy without matter; from one point of view the two are convertible terms. Before the birth of atoms all those forms of energy which become evident when matter acts upon matter could not have existed—they were locked up in the *protyle* as latent potentialities only. Coincident with the creation of atoms all those attributes and properties which form the means of discriminating one chemical element from another start into existence fully endowed with energy.

The pendulum begins its swing from the electro-positive side; lithium, next to hydrogen in simplicity of atomic weight, is now formed; then glucinum, boron, and carbon. Definite quantities of electricity are bestowed on each element at the moment of birth, on these quantities its atomicity depends,† and the types of monatomic, diatomic, triatomic, and tetratomic elements are fixed. The electro-negative part of the swing now commences; nitrogen appears, and notice how curiously position governs the mean dominant atomicity. Nitrogen occupies the position below boron, a triatomic element, therefore nitrogen is triatomic. But nitrogen also follows carbon, a tetratomic body, and occupies the fifth position counting from the place of origin. How beautifully these opposing tendencies are harmonised by the endowment of nitrogen with at least a double atomicity, and making its atom capable of acting as tri- and pentatomic. With oxygen (di- and hexatomic) and fluorine (non- and heptatomic) the same law holds, and one-half oscillation of the pendulum is completed. Again passing the neutral line the electro-positive elements sodium (monatomic), magnesium (diatomic), aluminium (triatomic), and silicon (tetretomic) are successively formed, and the first complete oscillation of the pendulum is finished by the birth of the electro-negative elements, phosphorus, sulphur, and chlorine; these three—like the corresponding elements formed on the opposite homeward swing—having each at least a double atomicity depending on position.

Let us pause at the end of the first complete vibration and examine the result. We have already formed the elements of water, ammonia, carbonic acid, the atmosphere, plant and animal life, phosphorus for the brain, salt for the sea, clay for the solid earth, two alkalies, an alkaline earth, an earth, together with their carbonates, borates, nitrates, fluorides, chlorides, sulphates, phosphates, and silicates, sufficient for a world and inhabitants not so very different from what we enjoy at the present day. True, the human inhabitants would have to live in a state of more than Arcadian simplicity, and the absence of calcic phosphate would be awkward as far as bone is concerned. But what a happy world it would be! No silver or gold coinage, no iron for machinery, no platinum for chemists, no copper wire for telegraphy, no zinc for batteries, no mercury for pumps, and, alas! no rare earths to be separated.

The pendulum does not, however, stop at the end of the first complete vibration; it crosses the neutral point, and now the forces at work are in the same position as they were at the beginning. Had everything been as it was at first the next element again would have been lithium, and the original cycle would have recurred, repeating for ever the same elements. But the conditions are not quite the same; the form of energy represented by the vertical line has declined a little—the temperature has sunk—and not lithium, but the one next allied to it in the series comes into existence—potassium, which may be regarded as the lineal descendant of lithium, with the same hereditary tendencies, but with less molecular mobility and higher atomic weight.

Pass we rapidly along the to and fro curve, and in nearly every case the same law is seen to hold good. The last element of the first complete vibration is chlorine. In the corresponding place in the second vibration we do not have an exact repetition of chlorine, but the very similar body bromine; and when for a third time the position recurs we see iodine. I need not multiply examples.

In this far-reaching evolutionary scheme it could not come to pass that the potential elements would all be equal to one another. Some would be unable to resist the slightest disturbance of the unstable equilibrium in which they took their rise; others would endure longer, but would ultimately break down as temperature and pressure varied. Many degress of stability would be here represented; not all the chemical elements are equally stable, and if we look with scrutinising eyes we shall still see our old friend the missing link, coarse enough to be detected by ordinary chemical processes, associated in the groups containing such elements as iron, nickel, and cobalt; palladium, ruthenium, and rhodium; iridium, osmium, and platinum. Whilst in their more subtile form these missing links present themselves as the representative of the differences which I have detected and described between the atoms of the same chemical element.

Dr. Carnelley has pointed out that "those elements belonging to the even series of Mendeleeff's classification are always paramagnetic, whereas the elements belonging to the odd series are always diamagnetic." On this curve the even series to the left, as far as can be ascertained, are paramagnetic, and, with a few exceptions, all to the right are diamagnetic. The very powerful magnetic metals, iron, nickel, cobalt, and manganese, occur close together on the proper side. The interperiodic groups of which palladium and platinum are examples are said to be feebly magnetic, and if so they form the exceptions. Oxygen, which weight for weight is more magnetic than iron, comes near the beginning of the curve, while the powerfully diamagnetic metals, bismuth and thallium, are at the opposite end of the curve.

On the odd, or diamagnetic half of the swing, the energy appears to have considerable regularity, whilst it is very irregular on the opposite side of the curve. Thus, between the extreme odd elements, silicon (28), germanium (73), tin (118), the missing element (163), and lead (208), there is a difference of exactly 45 units, conferring remarkable symmetry on one half of the curve. The differences on the even side are 36, 42, 51, 39, and 53 (giving the missing element between cerium and thorium an atomic weight of 180); these at first sight appear conformable to no law, but they become of great interest when it is seen that the mean difference of these figures is almost exactly the same as that on the other side of the curve—viz., 44·2.

This uniformity of difference—actual on the one side and average on the other—brings out the important inference that, whilst on the odd side there has been little or no variation in the vertical force, minor irregularities have been the rule on the even side. That is to say, the fall of temperature has been very uniform on the odd side—where every element formed during this half of the vibration is the representative of a strongly marked group—sodium, magnesium, aluminium, silicium, phosphorus, sulphur, and chlorine, whilst on the even side of the swing the temperature has sunk with considerable fluctuations, which have prevented the formation here of any well-marked groups of elements, with the exception of those of which lithium and glucinum are the types.

If we can thus trace irregularities in the fall of temperature, can we also detect any variation in the force represented by the pendulous movement? I have assumed that this represents chemical energy. In the early formed elements we have those in which chemical energy is at its maximum intensity, while, as we descend, affinities for oxygen are getting less and the chemism is becoming more and more sluggish. Part may be due to the lower temperature of generation not permitting such molecular mobility in the elements, but there can be little doubt that the chemism-forming energy, like the fires of the cosmical furnace, is itself dying out. I have endeavoured to represent this gradual fading out by a diminution of amplitude, the curve being traced from a photographic record of the diminution of the arc of vibration of a body swinging in a resisting medium.

* For brevity I call them by their dominant spectre band.

† "Nature presents us with a single definite quantity of electricity. . . . . For each chemical bond which is ruptured within an electrolyte a certain quantity of electricity traverses the electrolyte, which is the same in all cases."—G. Johnstone Stoney, "On the Physical Units of Nature." British Association Meeting, 1874, Section A. *Phil. Mag.*, May, 1881.

"The same definite quantity of either positive or negative electricity moves always with each univalent ion, or with every unit of affinity of a multivalent ion."—Helmholtz, Faraday Lecture, 1881.

"Every monad atom has associated with it a certain definite quantity of electricity; every dyad has twice this quantity associated with it; every triad three times as much, and so on."—O. Lodge, "On Electrolysis," British Association Report, 1885.

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When we look on a curve of this kind there is a tendency to ask, what is there above and below the portion which is seen? At the lower end of our curve what is there to be noted? We see a great hiatus between barium (137) and iridum (192·5), which it seems likely will be filled up by the so-called rare elements. Judging from my own researches, it is probable that many of these earthy elements will be found included in one or more interperiodic groups, whilst the higher members of the calcium, the potassium, the chlorine, and the sulphur groups, together with the elements between silver and gold, cadmium and mercury, indium and thallium, and antimony and bismuth, are still waiting to be discovered. We now come to an oasis in the desert of blanks. Platinum, gold, mercury, thallium, lead, and bismuth, all familiar friends, form a close little group by themselves, and then after another desert space the list is closed with thorium (233) and uranium (240).

This oasis and the blanks which precede and follow it may be referred with much probability to the particular way in which our earth developed into a member of our solar system. If this be so, it may be that on our earth only these blanks occur, and not generally throughout the universe.

What comes after uranium? I should consider that there is little prospect of the existence of an element much lower than this. Look at the vertical line of temperature slowly sinking from the upper to the lower part of the curve; the figures representing the scale of atomic weights may be also supposed to represent, inversely, the scale of a gigantic pyrometer dipping into the caldron where suns and worlds are in process of formation. Our thermometer shows us that the heat has been sinking gradually, and, *pari passu*, the elements formed have increased in density and atomic weight. This cannot go on for an indefinite extent. Below the uranium point the temperature may be so reduced that some of the earlier formed elements which have the strongest affinities are able to enter into combination among themselves, and the result of the next fall in temperature will then be—instead of elements lower in the scale than uranium—the combination of oxygen with hydrogen, and the formation of those known compounds the dissociation of which is not beyond the powers of our terrestrial sources of heat.

Let us now turn to the upper portion of the scheme. With hydrogen of atomic weight=1, there is little room for other elements, save perhaps for hypothetical helium. But what if we get "through the looking-glass," and cross the zero-line in search of new principles—what shall we find the other side of zero? Dr. Carnelley asks for an element of negative atomic weight; here is ample room and verge enough for a shadow series of such unsubstantialities. Helmholtz says that electricity is probably as atomic as matter;* is electricity one of the negative elements? and the luminiferous ether another? Matter, as we now know it, does not here exist; the forms of energy which are apparent in the motions of matter are as yet only latent possibilities. A substance of negative weight is not inconceivable.† But can we form a clear conception of a body which combines with other bodies in proportions expressible by negative quantities?

A genesis of the elements such as is here sketched out would not be confined to our little solar system, but would probably follow the same general sequence of events in every centre of energy now visible as a star.

Before the birth of atoms to gravitate towards one another, no pressure could be exercised; but at the outskirts of the fire-mist sphere, within which all is protyle—at the shell on which the tremendous forces involved in the birth of a chemical element exert full sway—the fierce heat would be accompanied by gravitation sufficient to keep the newly-born elements from flying off into space. As temperature increases expansion and molecular motion increase, molecules tend to fly asunder, and their chemical affinities become deadened; but the enormous pressure of the gravitation of the mass of atomic matter outside what I may for brevity call the birth-shell would counteract this action of heat.

Beyond this birth-shell would be a space in which no chemical action could take place, owing to the temperature there being above what is called the dissociation-point for compounds. In this space the lion and the lamb would lie down together; phosphorous and oxygen would mix without union; hydrogen and chlorine would show no tendency to closer bonds; and even fluorine, that energetic gas which chemists have only isolated within the last month or two, would float about free and uncombined.

Outside this space of free atomic matter would be another shell, in which the formed chemical elements would have cooled down to the combination-point, and the sequence of events so graphically described by Mr. Mattieu Williams in "The Fuel of the Sun" would now take place, culminating in the solid earth and the commencement of geological time.

And now I must draw to a close, having exhausted not indeed my subject, but the time I may reasonably occupy. We have glanced at the difficulty of defining an element; we have noticed, too, the revolt of many leading physicists and chemists against the ordinary acceptation of the term element. We have weighed the improbability of their eternal self-existence or their origination by chance. As a remaining alternative we have suggested their origin by a process of evolution like that of the heavenly bodies according to Laplace, and the plants and animals of our globe according to Lamarck, Darwin, and Wallace. In the general array of the elements, as known to us, we have seen a striking approximation to that of the organic world. In lack of direct evidence of the decomposition of any element, we have sought and found indirect evidence; we have taken into consideration the light thrown on this subject by Prout's law, and by the researches of Mr. Lockyer in solar spectroscopy; we have reviewed the very important evidence drawn from the distribution and collocation of the elements in the crust of our earth; we have studied Dr. Carnelley's weighty argument in favour of the compound nature of the so-called elements from their analogy to the compound radicles; we have next glanced at the view of the genesis of the element; and, lastly, we have reviewed a scheme of their origin suggested by Prof. Reynolds's method of illustrating the periodic classification.

Summing up all the above considerations we cannot, indeed, venture to assert positively that our so-called elements have been evolved from one primordial matter; but we may contend that the balance of evidence, I think, fairly weighs in favour of this speculation.

This, then, is the intricate question which I have striven to unfold before you, a question which I especially commend to the young generation of chemists, not only as the most interesting but the most profoundly important in the entire compass of our science.

I say deliberately and advisedly the *most interesting*. The doctrine of evolution, as you well know, has thrown a new light upon, and given a new impetus to, every department of biology, leading us, may we not hope, to anticipate a corresponding wakening light in the domain of chemistry?

I would ask investigators not necessarily either to accept or to reject the hypothesis of chemical evolution, but to treat it as a provisional hypothesis; to keep it in view in their researches, to inquire how far it lends itself to the interpretation of the phenomenon observed, and to test experimentally every line of thought which points in this direction. Of the difficulties of this investigation none can be more fully aware than myself. I sincerely hope that this, my imperfect attempt, may lead some minds to enter upon the study of this fundamental chemical question, and to examine closely and in detail what I, as if amidst the clouds and mists of a far distance, have striven to point out.

* "If we accept the hypothesis that the elementary substances are composed of atoms, we cannot avoid concluding that electricity also, positive as well as negative, is divided into definite elementary portions, which behave like atoms of electricity."—Helmholtz, Faraday Lecture, 1881.

† "I can easily conceive that there are plenty of bodies about us not subject to this intermutual action, and therefore not subject to the law of gravitation."—Sir George Airy. "Faraday's Life and Letters," Vol. II., p. 364.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Oct. 6.		Business Done Week Ending Oct. 6. Highest.		Lowest.
Anglo-American	35,	36	36½		35½
Do. Preferred	57,	58	58½		57½
Do. Deferred	11⅞,	12¼	13⅛		11⅞
Brazilian Submarine	10⅞,	11	10 15-16		10⅞
Cuba	11½,	11⅞	11½		11½
Do. Preference	18,	19	18½		—
Direct Spanish	1½,	2	—		—
Do. Preference	9,	10	9½		—
Direct United States Cable	9,	9¼	9¼		9
Eastern Telegraph	10⅞,	11⅛	11⅛		10⅞
Do. 6 per Cent. Preference	14½,	15	14⅝		14½
Do. 5 per Cent. Debentures, 1899	105,	108	—		—
Eastern Extension	11⅛,	11⅜	11⅜		11 1-16
German Union	9¼,	9½	—		—
Globe Telegraph and Trust	6⅛,	6⅜	6⅜		6 3-16
Do. Preference	13,	13½	13½		13
Great Northern	13½,	13½	13⅝		13½
Indo-European	35,	36	—		—
Reuter's	7,	7½	7½		—
Submarine	195,	205	197		—
West India and Panama	⅝,	¾	13-16		⅝
Do. 1st Preference	8½,	9	8⅞		—
Western Brazilian	6½,	6⅞	6 11-16		6½
Western Union 7 per Cent. 1st Mortgage	118,	122	—		—
Do. 6 per Cent. Sterling Bonds	101,	103	—		—

TELEPHONES.

Consolid. Telephone and Maintenance	13-16	15-16	—		—
Oriental	3-16	5-16	—		—
United Telephone	14⅜,	14⅝	14 9-16		14 7-16

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	2½,	2¾	2⅝		—
Do. (fully paid)	4,	4½	4⅜		—
Swan	⅞,	1⅛	⅞		—
Maxim Weston	3-16	5-16	¼		—

MISCELLANEOUS.

Telegraph Construction	39	40	39½		39½
India Rubber, Gutta Percha, and Telegraph Works	24	25	24⅜		24½

TRAFFIC RECEIPTS FOR SEPTEMBER, 1886.

Companies.	Sept., 1886	Sept., 1885.	Increase.	Decrease.
Cuba Submarine	2,250	2,160	90	—
Direct Spanish Telegraph	1,751	1,793	—	42
Eastern Extension	30,107	41,845	—	11,738
Eastern Telegraph	40,778	47,849	—	7,071
Great Northern	25,600	—	—	—
West Coast of America	3,585	—	—	—

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NOTES.

MEXICO.—Seventeen electric clocks are about to be erected by the Municipal Authority in the city of Mexico.

NEWCASTLE-ON-TYNE.—The Northern District Telephone Company have opened a public call office at the Newcastle Exchange.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 8th inst. were £2,904, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

THE INCANDESCENT LAMP LITIGATION.—We have received from Messrs. Woodhouse and Rawson a circular relating to the present position of this dispute and the course of action which they propose to pursue. The circular is much too long for us to reproduce, but we have no doubt that copies may be obtained upon application to Messrs. Woodhouse and Rawson.

THE OLYMPIA HALL, KENSINGTON.—This portion of the large building of iron and glass which is now nearing its completion at Kensington, and is intended to rival the Islington Agricultural Hall, is to be lighted by electricity. The installation will be provided by the Anglo-American Brush Corporation. The engines and boilers will be supplied by Messrs. Davey, Paxman, and Co., of Colchester.

THE GLOBE TELEGRAPH AND TRUST COMPANY.—The directors of this company have declared the payment of an interim dividend on and after the 21st inst. of 3s. per share on the preference shares, less income-tax, and of 6d. per share on the ordinary shares, income-tax having already been deducted for the quarter ending the 18th inst. The transfer books of the company are closed from the 14th to the 21st inst. inclusive.

THUNDERSTORMS.—On Sunday last the Manchester district was visited by a severe thunderstorm. Two houses are reported to have been struck by lightning, and considerable damage was done.—The Telephone Exchange at Sandusky, a town in Ohio, was recently struck by lightning, which, we are told, melted the 450 wires of the switch-board, and set fire to the tower of the exchange. Three girls climbed to the roof and put out the fire.

THE FRANKLIN INSTITUTE. — We have received the "Announcement and Programme of Lectures" of the Franklin Institute for the ensuing session. Out of thirty two lectures announced only three are on electrical subjects. Of these, two are by Mr. Carl Hering, on "The different forms in which electricity is manifested" and on "The electrical transmission of energy;" the third is by Mr. C. O. Mailloux, on "The storage of electrical energy."

BOOKS RECEIVED.—From Messrs. Longmans, Green and Co. we have received a copy of "The Gas Engine," by Mr. Dugald Clerk. We have also received from Mr. Brown, of Queen Victoria-street, a copy of the "Advertiser's A B C."—Mr. Rankin Kennedy, of Glasgow, sends us his illustrated descriptive price list of electric light appliances.—The Commissioners of the Victoria exhibit have sent us a copy of the "Illustrated Handbook of Victoria."

THE BRUSSELS EXHIBITION OF 1888.—At the Brussels International Exhibtion, to be held in 1888, it is proposed to erect a bridge spanning the exhibition buildings, and to run an electric railway up one side, down the other, and thence *viâ* a subterranean tunnel to the starting point. Without venturing to express too positive an opinion, we should like to ask if the Belgians are satisfied that this is really the very best and most useful thing that could be got for their money.

ELECTRICITY AND EDUCATION.—M. Henri Paget, Schoolmaster, of Geneva, has effected a reform as regards the vexed question of corporal punishment in schools. He employs a static machine and sparks his pupils' hands. We scarcely think this innovation is likely to commend itself to the London School Board; still, in the interests of the makers of scientific apparatus, we deem it our duty respectfully to direct the attention of the authorities to this mode of chastisement.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—At the general meeting of this company, to be held on the 4th Nov., the directors will recommend the declaration of a final dividend of 3s. per share, payable on the 5th proximo, making, with interim dividends already paid, a total of 6 per cent. per annum for the year ended 30th June last. £13,000 has been transferred to the reserve fund from the profits of the half year. The traffic receipts for the week ended 8th inst. amounted to £3,585.

TELEPHONY EXTRAORDINARY.—We have recently quoted an account of some remarkable experiments, which are alleged to have proved that a person in a mesmeric trance is capable of interpreting a telephonic message by mere contact with the line wire. We have now the authority of the *Journal d'Hygiéne* for the statement that a young lady, employed in a telephone exchange, who happened to be in a highly nervous condition, found that she was able to understand a conversation without lifting the receiver to her ears, by merely holding it in her hand.

THE HOLROYD SMITH TRAM LINE SYSTEM.—For purposes of demonstration a short tram line upon the Holroyd Smith system has been laid down near Paris, in a field not far from the Porte Maillot. The track is about 230 yards in length, and takes the form of a horseshoe, while the level also dips considerably in the sharpest part of the curve. The line is thus well calculated to exhibit the capacities of the system, and we are pleased to hear that a car carrying 45 passengers has been tried upon it very successfully. The line has already been visited by several prominent French engineers.

FRENCH JUBILEE OF RAILWAYS.—The Jubilee of the introduction of railways into France will be celebrated in Paris next year. On this occasion there will be held:—1. An international exhibition of railways and industries connected with them, including electrical appliances, which will be open from May to October, 1887. 2. An international congress, composed of delegates of railway companies, chambers of commerce, scientific societies, and others. Every information can be obtained from M. A. Lewis, Commissioner-General for England and the Colonies, New Broad-street House, E.C.

POPULAR ELECTRICITY IN THE MIDLANDS.—Messrs. Chamberlain and Hookham send us an amusing account of the effects produced upon the minds of rural excursionists who have inspected their exhibits at Bingley Hall. One countryman was hard to persuade that a dynamo and a gas engine were not convertible terms. Others thought that dynamite and diamond cutting must be intimately related with dynamos; while the more scientific explained to their benighted relatives that the current was produced by the friction of the armature coils. The latter view, however, is by no means confined to the Birmingham district.

THE ELEVATED RAILWAY OF NEW YORK.—In addition to the Sprague system of electric railways, which we describe at some length in the present number, the Daft system is also being experimentally tried upon the New York elevated lines. It will be remembered that this system had a trial some months ago. Owing, however, to an error in the data supplied to the Daft Company as to the amount of power which would

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be actually required for the ascent of the steepest gradient, the motors at first supplied were not sufficiently powerful, and had to be withdrawn. We understand that the cars will very shortly be replaced upon the lines with proper equipment.

THE CUSHMAN TELEPHONE.—A suit is pending in the United States Circuit Court at Chicago, in which the Bell Telephone Company is the complainant. The defendant is the American Cushman Telephone Company. This company claims to ante date all known telephone patents, on the ground that Cushman constructed and publicly operated a telephone at Racine, Wis., in 1851. The Cushman patent is claimed to be identical with that of Prof. Bell. The American Cushman Telephone Company was incorporated a short time ago, and set out to manufacture and sell telephones, but the Bell Company immediately filed a bill in the Circuit Court, praying for an injunction.

THE ST. ETIENNE INSTALLATION.—A singular thing happened the other day at St. Etienne, where there is a large central station on the Edison system, of which we recently gave some account. During a severe thunderstorm it was observed that many of the incandescent lamps were repeatedly illuminated for several minutes at a time. This story has been going the round of the French press, under the title of "Curious Effects of Lightning." The case is one of those in which the explanation would appear the most satisfactory to those who least understand the conditions involved. However, a very simple and satisfactory explanation of the phenomenon has now been given. It appears that upon the day of the storm a new ammeter was being tested at the central station—that is all.

TELEPHONES IN THE WEST.—The Western Counties and South Wales Telephone Company continue to extend their operations in various directions. Exchanges will shortly be opened in the following towns, in addition to the list which we gave some few weeks since:—Llanelly, Shrewsbury, Hereford, Weston-super-Mare, and Weymouth. The trunk line which is now being erected between Bristol and Swansea (a distance of 106 miles) will have intermediate stations at Newport, Cardiff, Pontypridd, Treherbert, and Briton Ferry, Another trunk line, forty miles in length, will connect Swansea, Landore, Morriston, Neath, Briton Ferry, and Port Talbot; and a third will run from Pontypridd to Merthyr Tydvill, *via* Aberdare. It is expected that all these extensions will be in operation before the close of the year.

THE POLLAK CELL.—This cell may now be seen in action at the offices of Messrs. G. Binswanger and Co., 5, Great St. Thomas Apostle, E.C., and we should recommend those electricians who are interested in primary batteries to avail themselves of the opportunity of inspecting it. To prevent misapprehension it may be useful to state that although the cell is well adapted for maintaining a limited number of small lights for a few hours at a time, yet it does not pretend to compete with other batteries which have been specially designed for incandescent lighting on a large scale. The special value of the cell arises from the fact that owing to its self-regenerative powers, it may be left entirely without attention for months together, while continuing every day to furnish a certain quantity of current. This is a feature which will recommend it for telegraphic, telephonic, and electric bell work, and for all purposes where batteries are to be placed in unskilled hands.

TELEPHONE DEVELOPMENT IN AUSTRIA.—The Austrian Government has authorised the connection of the various telegraph offices in the towns of Prag, Graz, Trieste, Bielitz, and Reichenberg, with the Telephone Exchanges there, for the purpose of telephonic transmission and delivery of telegrams to subscribers. The increase of subscribers in the towns worked by the Consolidated Telephone Construction and Maintenance Company, viz., Prag, Graz, Trieste, Lemberg, Czemoritz, Bielitz-Biala, Pilsen, and Reichenberg, has of late been very marked, the number of subscribers now amounting to 1,600. The average price of subscription is about 85 florins, out of which 10 florins have to be paid as royalties. In spite of this the Company has successfully overcome the numerous difficulties which had to be surmounted in introducing the telephone into Austria, and is now in a fairly prosperous condition.

LIGHTING OF THE "GREAT EASTERN."—The "Great Eastern," which left Liverpool for Holyhead on the 8th inst., has been lighted since the middle of May last by the Jablochkoff and General Electricity Company. The deck of the "Great Eastern" is lighted by forty 400-candle Jablochkoff candles, mounted on standards 12ft. high, and presenting an imposing appearance from the river. They are maintained by two of the company's 20-light dynamos, with a 10-light machine in reserve. The motive power is supplied by a horizontal single-cylinder donkey engine, which, in the daytime, drives the bilge and other pumps. This heavy and almost constant work is not conducive to a good maintenance of the joints or regularity of action, and great difficulty was experienced in consequence by the electrician, Mr. H. E. Mitchell. One day the governor belt slipped off, but the engine did not seem to run more unsteadily, and so it was not put on again, and the working has been more regular than before. It is intended to light the saloon with incandescent lamps.

A TELEPHONE "RETURN SIGNAL."—In a paper read before the Electrical Section of the American Institute by Mr. P. Gannon, the author remarks that battery call bells have an advantage over magnetos, because by listening at the telephone the person giving the call can hear the vibrator at the other end if the circuit is in good order. Whenever battery calls are used, this method may be employed with advantage as a daily test. Nevertheless, the undoubted advantages of the magneto call led the author to devise a comparatively simple attachment whereby the same advantage may be secured for the latter system. This consists of a freely suspended pendulum carrying either a wire coil or a permanent magnet attached to the bob; the pendulum is set in motion by the stems of the vibrators of the magneto bells, and continues to swing for a few seconds after the call has been given. It is easily seen that induced currents may be sent upon the line by this means, and in this way by listening on the telephone at the first station, it is known at once whether the call has been received—always provided, however, that the "induction" already on the line is not too great.

THE BARTHOLDI STATUE OF LIBERTY.—"After nearly three years of study and deliberation," says the (New York) *Electrical World*, "the manner of lighting the Bartholdi statue of 'Liberty Enlightening the World' has been definitely decided upon. The plan adopted is one which is in conformity with the general design of the statue itself, and which will add to its beauty in a marked degree. The torch of the statue will contain 8 lamps of 6,000 candle-power, the light from which will be thrown directly up into the clouds. This powerful beam, together with the cloud illumination, will constitute a beacon which will be visible probably a hundred miles out to sea, and will thus, afar off, be symbolic of the light and liberty to be enjoyed by the visitors to our shores. At the foot of the statue four or eight lights of 6,000 candle-power each will be distributed. Their light will

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be reflected upon the statue, and will illuminate it brightly. All these arc lamps will be invisible themselves, so that the objections raised by the river pilots against the blinding effects of the light will be entirely removed. Besides the arc lights all around the statue, the diadem upon the head of the figure of Liberty will contain incandescent lamps, to give the effect of jewels."

THE TOWER SYSTEM OF ELECTRIC LIGHTING.—Although it can scarcely be doubted that the system of illuminating a town by means of a number of powerful arc lights placed upon lofty towers or posts, from 100 to 150 feet in height, is one of the most extravagant that could be devised, it yet appears that the system gives great satisfaction to the inhabitants of the towns in America where it has been introduced. In writing of the recent meeting of the American National Electric Light Association, the (New York) *Electrician and Electrical Engineer* says :—"In advocating the claims of Detroit as a suitable place for holding the August meeting, the inspection of the tower lighting system proved a most successful argument in favour of that city. We have never experienced so general a change in opinion, caused by actual observation, as there was upon this subject. A large number of the visitors were strongly prejudiced against the tower system, but after thorough examination became its earnest supporters." An enthusiastic correspondent of the same paper, after describing the avenues for which Detroit is famous, writes :—"At the entrance to one of these high-arched primeval temples we would suddenly come pat upon an arc light on a telegraph pole, its daring brigand-like flicker and stare nearly blinding every one, while everywhere apart from these uncanny spots, the diffused rays of a portion of the 576 tower lights, either too high above us to be unpleasant, or too far away to be dazzling, cast in every direction a gentle, soft, moonlight sort of illumination, which was a complete and glorious surprise to all."

COMPASS ERRORS.—We have lately heard of several remarkable stories as to deviation of the compass, but it would be difficult to beat the following, which we take from the *Toronto Mail* :—"A strange phase of the mystery of the compass was made manifest on the occasion of a recent cruise of the 'Cygnet.' The yacht left Toronto for a run across the lake to Niagara. Everything was fair and smiling. A large party of jolly people were on board, who enjoyed the trip greatly. It was found when they came within hail of land that they were seven miles out of their course, having come out opposite Wilson, N.Y. The commander was greatly troubled. It was decidedly a reflection on his seamanship, and he was exceedingly annoyed. He regarded the compass suspiciously, and carefully examined its surroundings, but could discover nothing that would account for any vagaries on its part. While he was standing gazing gloomily at the tremulous needle it gave a sudden start. The commander looked up and found that a stout member of the party had in the meantime approached. As he passed the needle followed his movements, and finally when he stopped at the bow the needle pointed straight at him. A series of experiments were then instituted, and it was found, when the stout gentleman was near, that the pointer followed him. He admitted that for some weeks past he had been indulging in the wild delights of an iron tonic, and he was afraid that his system had become permeated with the metal. This explanation was accepted by all, and the secretary was requested to communicate the facts to the Philosophical Society."

TUNING FORKS MAINTAINED BY ELECTRICITY.—In a recent number of the *Philosophical Magazine*, Prof. S. P. Thompson suggests an improvement in the method usually adopted for maintaining the vibration of tuning forks by electricity. This arrangement, which is originally due to Koenig, consists of an electro-magnet placed between the prongs and a stylus which makes contact with a platinum headed screw, and breaks the circuit when the magnet is excited, just as in the ordinary bell "trembler." With this arrangement it is, however, impossible to obtain a perfectly uniform and regular rate of vibration. Even when the pitch is approximately constant, the phase is continuously varying. Prof. Thompson points out that these irregularities arise from the fact that the impetus is given at the wrong instant of the motion, namely, at some other instant than that during which the fork is passing with maximum velocity through zero position of displacement. The professor is, however, able to indicate a very simple solution of the difficulty. He proposes to take two forks (which must, however, be in perfect unison with each other), and let each act as interruptor to the other, but not to itself, the electro-magnets of either fork being included in the circuit of the contact points of the other. One battery will suffice for the two, for they will not both make contact at the same time. The forks, when once started, will settle down to a difference of phase corresponding to an almost exact quarter of a period; hence each will close the circuit of the other when the latter is passing through the most favourable position, that, namely, of its normal position when at rest. Under these circumstances there will be no further tendency to vary either in phase or in period. It is also pointed out that the contact points should be affixed at, or near, the middle of the length of the prong, and not at the end, as is usually the case. In the former position the contact is much more firmly made, and is quite sufficiently long in duration.

SUBMARINE CABLES IN TIME OF WAR.—In the document published by the *Pall Mall Gazette* on Wednesday evening, purporting to be a copy of a memorandum addressed to the Admiralty by the junior lord (Lord Charles Beresford), the following paragraph occurs. We offer no opinion as to the authenticity of the *Pall Mall's* information, but have no doubt that its statements relating to our cables are substantially true :—"In these days of electricity and great speed the first point scored may save millions to the country which secures it, and have the probable effect of winning the campaign. This remark applies with particular force to our foreign stations. Through want of organisation and systematic instruction, as well as want of ordinary foresight, the Admiralty render it possible for an enterprising enemy, like France or Russia might be, to easily score this first advantage, because a delay of two days is allowed to elapse owing to the antiquated formalities of the present system before the Admiralty could communicate the proclamation of war to the Commanders-in-Chief of different stations. It should be arranged immediately that the English commanders on foreign stations shall be in a position to receive the news of war being declared as soon as, if not before, the enemy. The delay which must occur under the present system would be fatal on such stations as China or Australia, where there is floating wealth of enormous value, as the enemy during the interval referred to would cut the cables, and so the first intimation of hostilities to the English fleet might be the sinking of valuable merchant vessels or even English men-of-war. I know for a fact from a conversation with Captain S——, of the Russian ship L——, that it is one of the chief provisions in their scheme of preparations for war that the enemy's telegraph wires should be cut at certain indicated places, and it was inferred that, whatever country Russia was at war with, the British submarine wires would be cut, as the news of the whole world passes through them. There is

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good reason to believe this was contemplated in 1885, as it is an actual fact that Russian men-of-war were stationed at all the most important cable centres."

ATMOSPHERIC ELECTRICITY.—Since the month of October, 1883, constant observations of the electrical condition of the atmosphere have been undertaken at the meteorological observatory at the University of Odessa. The observations have been made by means of a water collector, having a nozzle 1·5 meter in length, and placed at such a height that the jet of the water breaks into globules at a distance of 14 metres above the ground. It is well known that under these conditions the collector will assume the same electrical potential as that of the air at the point where the jet is broken up. The potential is measured by means of a Thomson quadrant electrometer. The potentials are given in terms of the number of elements of a copper-zinc-water battery, which served to balance the deflections of the electrometer index. The lowest potential recorded was on a very calm day in October, 1883, when it was equal to 90 elements. On January 16th of the following year, under a cloudless sky and a low temperature, the potential was found to be equal to that of 24,600 elements (assuming a proportionate deviation of the index), while a few days later the needle for the space of three minutes reached the extremity of the scale, and indicated still higher figures. The readings frequently vary over a wide range from one minute to the next. Some tables are given as examples, showing that in the space of a few minutes the potential has ranged from 1,200 up to 4,500 units. On another occasion, in ten minutes the potential fell from 24,600 to 1,050 elements. On the other hand, periods of considerable electric stability are sometimes recorded. On 27th December, 1883, the needle was observed to remain absolutely motionless for thirty minutes, although a slight wind was blowing at the time; again on the 23rd October of the same year the deflection of the needle continued constant for one hour. In each of these cases the potential reading was very low. The observations are believed to have established the fact of the existence of an intimate connection between the variations of atmospheric pressure and electricity. But the interpretation of the phenomena observed is so greatly complicated by local conditions, such as fogs, smoke, and dust that it is extremely difficult to obtain decisive evidence. Some of the figures given above seem to us to be highly remarkable, and we deem it unfortunate that further information has not been given as to the meteorological conditions on these occasions.

QUANTITATIVE CHEMICAL ANALYSIS BY ELECTROLYSIS.—The *Chemical News* contains a paper upon this subject by Mr. T. Moore, of which the following is an abstract:—"When solutions containing either iron, cobalt, nickel, zinc, cadmium, aluminium, chromium, or manganese, are treated with phosphoric acid and ammonium carbonate, and are electrolysed, the first five are completely precipitated, chromium forms a soluble chromate, manganese is partially deposited as oxide on the other electrode, whilst the aluminium is unaltered. For separate determinations of the first five, the following plan answers well:—The slightly acid solution of ferric (or other) *sulphate* or *chloride* is treated with a solution containing 15 per cent. of glacial phosphoric acid until the yellow colour disappears, ammonium carbonate is added in large excess, and the whole warmed gently until the solution is clear. On electrolysing the hot solution (70°) with a current equal to 1,200 or 1,300 c.c. mixed gases per hour, the iron (or other metal) is deposited rapidly and completely. A current equal to 100 to 300 c.c. of mixed gases per hour is sufficient to effect the deposition of the zinc, whilst a current of 40 c.c., which gives no deposit with zinc, is strong enough for cadmium. A good solution for the electric deposition of either zinc or cadmium is prepared by precipitating the solution of a zinc or cadmium salt with sodium phosphate, dissolving the precipitate in potassium cyanide, and adding excess of ammonium carbonate. This solution when electrolysed at 80° with a current equal to 1,000 c.c. of mixed gases per hour gives a rapid and complete deposit. Zinc is best deposited on silver-plated electrodes. For copper, the freshly precipitated sulphide dissolved in potassium cyanide, and mixed with excess of ammonium carbonate, is recommended. Manganese is best estimated by deposition as oxide on the positive electrode from a slightly acid solution of nitrate or sulphate; it is, however, interesting to note that a large proportion is deposited as metal by electrolysing with a powerful current a neutral solution containing a large excess of ammonium thiocyanate. For bismuth, sufficient tartaric acid is added to prevent precipitation of basic salt, the solution is rendered strongly alkaline with ammonia, mixed with considerable excess of glacial phosphoric acid, and electrolysed at first with a weak (20 to 30 c.c. gas per hour) current, subsequently with a current = 450 c.c. gas. Tin is easily precipitated from either acid or alkaline glacial phosphoric acid solutions. An attempt to estimate arsenic as AsH_3 by electrolysing its acid solution in presence of zinc sulphate was not successful."

AMERICAN VIEWS UPON ELECTRIC LIGHTING.—The following extract from the (New York) *Mail and Express* will serve to show in what light electrical matters are at present regarded by the American public:—"The Electric Light Convention that has just closed its sessions in Detroit not only showed what an important illuminator electricity has come to be in this country, but also what a variety of interests and industries are bound up in the general business of electric lighting. If specialisation is a sign of progress in any industry—as it must be, according to the evolution theory—electric lighting must have made tremendous strides in the few years of its existence. And it has. It is past the first period of speculative existence, and has settled down into a conservative business on pretty well established principles. If the electric light has done nothing more than stir up the gas companies, and frighten them into providing better light for less money, it would have been of immense benefit to the public. Since it became evident that there was a serious probability that electricity would become a competitor of gas, more attention has been paid to the improvement and cheapening of processes of gas manufacture, and to economising in its use. In almost every place where the electric light has been introduced at all, the gas service has been cheapened and bettered; and even the rumour of a possible establishment of an electric plant has often sufficed to bring down the gas companies. All this, however, is what may be called the negative result accomplished by the application of electricity to illumination. Its positive results have been far more important and beneficial. Local companies are organising in all directions; manufacturers have their facilities taxed to the utmost to keep up with the demands of their business; in many places even the gas companies, with wise foresight, have taken the bull by the horns, as it were, and themselves established plants for electric lighting. In the early days of the new industry, there was necessarily a good deal of speculation about it; but now there are a dozen systems of lighting that have demonstrated their practicability and usefulness; and it is a business enterprise on the same footing as any other—with no greater uncertainties and no greater prospective profits—to organise a

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company for this purpose. Constant improvements are being made in the details of manufacture and construction of machinery and other 'plant' for electric lighting; and these improvements for the most part available for the use of the trade. We may expect, therefore, to see constant advances made in the efficiency of the machinery, and constant reductions made in the expense. It is as certain as anything future can be that American cities, and, eventually, all civilised cities, will be well and cheaply lighted."

ON THE ELECTRICAL CONDUCTIVITY OF GASES AND VAPOURS.—M. Jean Luvini, in the *Comptes Rendus* for September 13th, writes as follows:—From the experiments of Becquerel, Grove, Matteucci, Marrangoni, Agostini, and others, it follows that gases and vapours are very bad conductors of electricity. Grove demonstrated this proposition for air at very high pressures; Becquerel and Matteucci for very low pressures (1 to 3 millim). MM. Mascart and Joubert place air and vapours and generally all gases in the class of bad conductors; and Sir W. Thomson has stated that aqueous vapour is an excellent insulator. Notwithstanding this we still read in treatises on physics, and it is repeated in lectures, that moist air and vapours conduct electricity; and this very serious error is the base of several theories. I have made several sets of experiments on this subject, the results of which, combined with those of other experimenters, have led me to conclude that *gases and vapours, whatever be the pressure and temperatures, are perfect insulators, and cannot be electrified either by friction with each other or with solids or liquids.* I arrange the experiment so that the fluids in which the electrified bodies are introduced cannot be deposited as liquid on the whole length of the insulating supports. In a large room a long thread consisting of seven cocoon fibres, without torsion and without joints, is stretched. In its centre is suspended a hollow brass sphere 5in. in diameter. A second thread, similar and parallel to the first, supports a pith ball pendulum, which, when not electrified, is in contact with the brass sphere. I usually electrify the sphere with the conducting disc of an electrophorus. The extent of the room and the purity of the air enable me to fill the space about the electrified bodies with a considerable quantity of the gas or vapour which I am investigating, without these fluids settling for a time on the long thread. In this way, apart from the small conductivity of the wires, and the losses due to dust in the air, any diminution of the electrical tension observed must have been due to the conductivity of the fluids experimented on. I always electrified the sphere almost to the same tension; I then observed the time in which the deflection fell a certain number of degrees, first in air and then by surrounding the sphere and the pendulum by a dense atmosphere of the gas to be studied. I worked thus with air saturated with aqueous vapour at various temparatures from 16° to 100°; hydrogen and carbonic acid not dried, but as they emerge from the bath in which they are produced; air heated by charcoal or by the flame of a candle, the smoke of an extinguished candle, the fumes of burnt sugar, incense, &c. None of these substances showed any trace of conductivity. In one set of experiments, instead of cocoon threads I used ordinary sewing-thread stretched horizontally, and with a double pendulum in the centre provided with pith balls. The results did not change, but when I worked with aqueous vapour at high temperatures, the divergence diminished rapidly by a certain quantity and then became again almost constant. This effect is due to the vapour which is deposited on the larger and less insulating wire, and to the fact that the small quantity of electricity of the balls becomes divided between the thread and the balls themselves.

THE PARIS CREIL EXPERIMENTS.—We learn from *L'Electricien* that a further report upon the Paris Creil experiments has recently been privately circulated among certain circles in Paris. This document seems to be of considerable length, consisting of fourteen distinct sections; but, judging from the abstracts given by our contemporary, we gather that the only matter of any general interest is that contained in the two last sections, and which *L'Electricien* reproduces at full length. From these statements it appears that upon the 27th of May a special meeting of the sub-committee charged with the experimental work was held at Creil in order to determine the characteristic of the generator. But we venture to think that by the time our readers have grasped the facts which we are about to place before them they will agree with us that the curve obtained is much more strongly characteristic of the committee itself than of the dynamo under discussion. A few words will explain our meaning. The machine at Creil has always been described, hitherto, as having its field-magnets separately excited. It is therefore scarcely necessary to say that the characteristic of the machine might be expected to follow a (very nearly) right line, commencing at some height upon axis Y, and, more or less, inclining towards axis X, owing to the increasing strength of the magnetic field of the armature. But, so far from conforming to this type, the curve before us looks very much as if it had been taken from a well-designed compound-wound dynamo. Commencing at the point of origin it rapidly rises, and soon becomes sensibly parallel to the axis X. The explanation which will naturally suggest itself at first sight is that for the purposes of this particular experiment the machine had been made to excite itself, though even upon this supposition it would be difficult to account for the phenomenon of the horizontal limb. But accompanying the figure is a table containing the numerical data from which the curve is supposed to have been drawn, and from this we find that the current through the field-magnets was usually about ten times as great as that through the armature, so that the fact of separate excitation is fully established. *L'Electricien*, after having noted this discrepancy, dismisses the subject with a few highly sarcastic observations. We confess, however, that our own curiosity was somewhat aroused, and we were anxious to discover, if possible, in what way the curve could possibly have been obtained from the figures in the table. In the first place it appears, both from the table and from an accompanying note, that the curve has been constructed from only three sets of co-ordinates. And on further examination it appeared that these points all lay well outside the curve as given—which, by-the-bye, it should be mentioned is reproduced in fac-simile by our contemporary. Now, these points are all situated near the upper part of the curve, *and would equally well suit the normal characteristic of a separately excited dynamo.* It is true that the third point, if plotted from the volts and amperes given in the table, would be about 25 per cent. too high; but upon referring to the column of velocities it appears that the speed had now increased from 121 to 158 revolutions per minute. At the same time the exciting current seems to have been considerably increased. If, however, the ordinate be reduced in proportion we get a perfectly normal curve. It is superfluous to add further comment, but it can scarcely be doubted that had the members of the committee taken the trouble to acquaint themselves with the elementary facts of electrical engineering they would not have been at the pains of plotting an imaginary curve when a straight line would have certainly answered the purpose so very much better.

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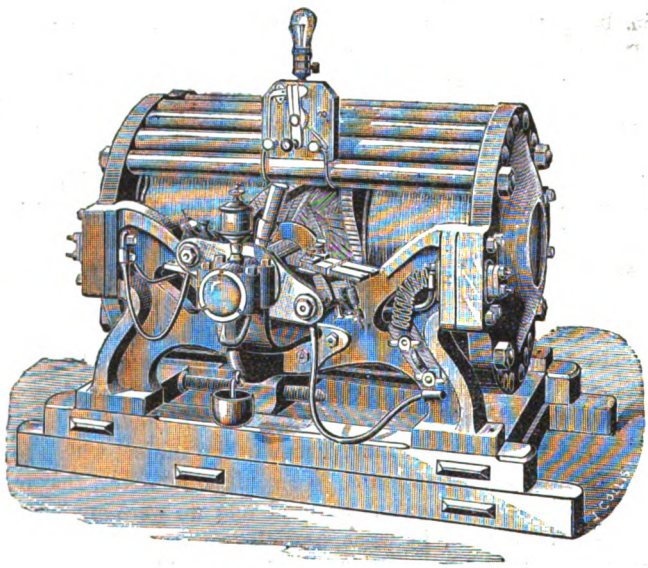
THE NEW THOMSON INCANDESCENT DYNAMO.

The Thomson-Houston Company have hitherto achieved all their success by means of their remarkable high-tension machine, and when incandescent lamps have been demanded they have hitherto contented themselves with running them upon multiple-series circuits furnished with automatic switches for maintaining constant resistance in each branch. Prof. Thomson has, however, at length designed a low tension machine specially for incandescent lighting work. This machine is illustrated in the accompanying engraving, which we reproduce from the columns of the (New York) *Electrical World*.

It will be seen that in its general arrangement the new dynamo bears a very close resemblance to its predecessor; there is the same disposition of the field-magnets and the same spherical armature. The coils of the latter, however, no longer conform to the "open circuit" type; but are, in fact, wound in numerous sections in a manner very much resembling the well-known "Siemens" winding. The arrangement of the connections between the coils and the bars of the commutator is somewhat peculiar. The wires are carried along the shaft into the body of the armature as far as its middle point, then radiate outwards, and are soldered to the coils around a "great circle" of the sphere. The armature



The new Thomson Incandescent Dynamo.

core is constructed of rings of annealed sheet iron (of different diameters presumably), which are carried by hubs on the shaft.

The field excitation is in some respects unique. Although the machine is compounded for constant potential, yet the magnets are wound with shunt coils only. This paradox is explained by the fact that the series coils are placed *between* the field-magnets, and directly over and around the armature, so as to exercise an immediate influence upon the armature core and wire. And further, the plane of this series coil is inclined at an acute angle to the plane of the principal magnetic field, this angle being so adjusted as exactly to compensate for the distortion of the field which would otherwise be produced by the polarity of the armature.

Considering the comparatively small amount of iron in the field-magnets, it is probable that but for this arrangement the machine would suffer considerably from sparking. It will be seen that Prof. Thomson has overcome the difficulty with his usual originality and ingenuity, and this new departure will certainly be watched with much interest. We learn that machines of 75, 110, and 150 volts have been constructed upon this plan with considerable success.

We hope before long to be able to publish some further electrical details.

A NEW RESISTANCE GOVERNOR.

We illustrate this week a resistance governor, lately brought out by the Woodhouse and Rawson Electric Manufacturing Company. These apparatus are intended to automatically regulate the amount of resistance in any electric circuit, and are made in two different types, the larger form being intended for heavy currents, and consequently principally used with resistances in a main circuit, and the lighter form being for smaller currents and adapted for use in the field-magnet circuits of dynamos when resistances have to be inserted or withdrawn to keep the E.M.F. of the machines constant.

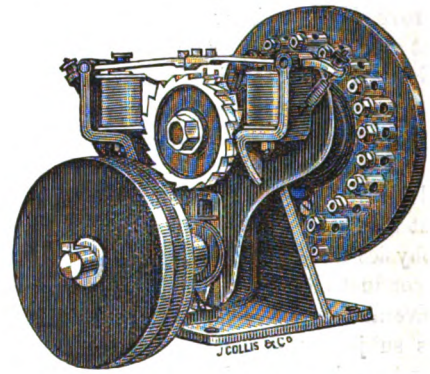


Fig. 1.—The Woodhouse and Rawson Resistance Governor.

A very short description will make the action of these governors quite clear. A switch arm attached to the same spindle as a pair of ratchet wheels with teeth in opposite directions, moves over a number of contact plates, between which are connected the units of resistance. These contact plates, as will be seen by the engraving, Fig. 1, are placed on a circular insulating disc attached to one end of the standard in the large governor, and in the small governor are mounted on the base board. On a continuation of the spindle carrying the switch arm and ratchet wheels is mounted a rocking frame, which is continually driven, through a crank disc, pin and block, by any convenient part of the moving machinery, from which a belt passes over the pulleys of the governor. The rocking frame carries two electro-magnets, the armatures of which act as pawls on the two ratchet wheels respectively when one or other of the magnets is excited.

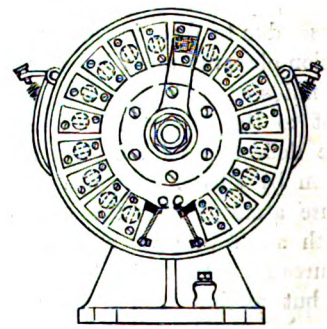


Fig. 2.—Front Elevation.

These governors are controlled by a regulator, arranged to make one of two contacts, and close one or other of the two electro-magnet circuits on the governor, when the E.M.F. or the current (whichever the apparatus is arranged to control) in the regulator is above or below its normal value. When this takes place, the electro-magnet excited draws down its armature, which engages with its ratchet wheel, and drives it and the switch arm forward to the next contact plate. By making the pitch of the teeth of the ratchet wheels of the same angular dimension as the distance between the centres of the contact plates, and properly arranging the travel of the rocking frame, the switch arm always moves forward until it is in its proper position on one of the contact plates.

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By slightly altering the switch part of the governor it can also be arranged as an automatic accumulator switch to cut in or out cells, as the condition of the E.M.F. of the circuit may require.

We are assured that the governor is perfectly positive and dead-beat in its action, and it is thoroughly well designed and strongly made.

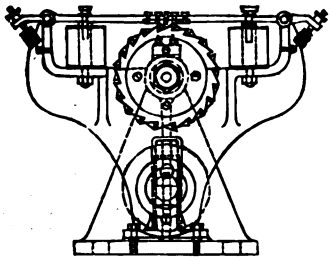

Fig. 3.—Back Elevation.

It is well understood by electrical engineers that governors of this type, which directly control the dynamo, are chiefly of use where the engine employed has to do other work, in order that the machine may thereby be rendered independent of fluctuations in the speed of the engine. This resistance governor is a modification of the Porte-Manville Electric Engine Governor, which our readers will remember was described some time ago in our columns.

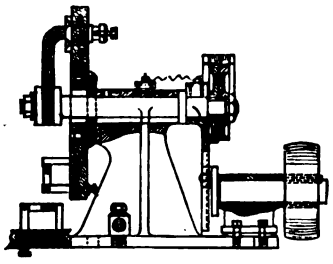

Fig. 4.—Section.

We understand that the first four of these governors were made for Sir David Salomons, and are now in daily use for the regulation of resistances and accumulators in his large installation at Broomhill.

THE GREAT BRUSH DYNAMO.*

By Dr. Robert H. Thurston, Director Sibley College, Cornell University.

The process of reduction of aluminum and other metals, and production of alloys, invented by Messrs. E. H. and A. H. Cowles, and perfected with the assistance of Prof. Mabery, of Cleveland, O., has attracted the attention of engineers, as well as of men of science, not only on account of the ingenuity, simplicity, and effectiveness of the process itself, but also, and probably quite as much, because of its bringing into use the voltaic arc and dynamo-electric machines of exceptional and enormous power.

The writer was recently so fortunate as to be able to stop in Cleveland long enough to witness the operation of the process, and to be present at the first trial of the great dynamo recently completed by the British Electric Company for the Cowles Electric Smelting and Aluminium Company.

The Cowles process, it will be remembered, consists in the passage of a powerful current of electricity from a "dynamo" through a mass of ore mixed with carbon and other material forming the "charge," until the action of the heat, and possibly of the electrical force, causes a reduction of the ores and the formation of an alloy of the metals so reduced.

* Read at the Buffalo Meeting of the American Association for the Advancement of Science, August, 1886. From the *Journal* of the Franklin Institute.

The apparatus consists simply of a powerful dynamo-electrical machine, connected with a pair of carbon electrodes of correspondingly exceptional size, these electrodes being enclosed in a furnace of brickwork, lined with the most refractory available material. The Cowles Company have several dynamos all of large size, but it is the intention of the writer to describe but one, the latest built and the largest. The next smaller, which was until recently considered a very powerful machine, weighs about two tons and a half, is driven at 900 revolutions per minute, and produces a current of 1,575 amperes, with an E.M.F. of 45 volts. These machines are "shunt-wound" and very nicely proportioned under the direction of the inventor, Mr. Charles F. Brush, whose interest in the work induced him to give to this construction his personal attention. The largest machine, recently completed, and under test at the time of the visit of the writer to the works, weighs 21,900 pounds (9,934 kgs.), a so-called 42in. (1060·6 mm.) machine, the armature having that diameter. The armature contains 1,600 pounds (725·7 kgs.) of iron; it carries 825 pounds (378 kgs.) of copper wire, while the field-magnets are wound with about six times that weight, 5,424 pounds (2641·8 kgs.).

The armature of this great dynamo consists of 16 bobbins, each carrying 21 turns of best copper wire, two strands lying side by side, the wire being 0·35in. in diameter (8·89 mm.). These 16 bobbins are operated in multiple arc, thus giving about 32 strands of copper wire of the diameter above stated, and about 65ft. (19·8 m.) long. Sixteen copper bars carry the current from the bobbins to the commutator, each car being 1in. by ½in. (25·4 mm. by 12·7 mm.) in section. The two commutators are coupled in multiple arc.

The field-magnets are eight in number, and consist of a cylindrical cast-iron core, 11in. (279·4mm.) in diameter, by 16in. (406·4mm.) in length, and wound with thirty layers of one hundred and two turns each, of copper wire, 0·134in. (3·404mm.) in diameter; all the eight wires are coupled in multiple arc as in a shuntfield. Thus combined they have a resistance of about one ohm, total, cold. The pole pieces are of peculiar form, and fitted carefully to the field.

The driving shaft, carrying the armature, is 13ft. (3·962m.) long, and 5½in. (139·7mm.) in diameter in the main bearing; it is made of open hearth steel, furnished by the Otis Company. The machine is driven by means of a 44in. (1117·6mm) double belt, turning a 40in. (1,016mm.) pulley on the armature shaft. The machine occupies a space on the floor about 15ft. (4·572m.) long, and 4ft. (1·219m.) wide, and stands about 5ft. (1·52m.) high.

This dynamo was calculated to furnish a current of 3,200 amperes, with an electromotive force of eighty volts, with a normal maximum current in the field of eighty amperes, the speed of rotation not to exceed 600 revolutions per minute. Its actual speed was a little above 400 when doing the full amount of work demanded. The maximum field is thus obtained with but about two and one-half per cent. of the normal current (3,200 amperes), and falling to one per cent. when less E.M.F. is needed. When in operation, the writer found no observable heating in any part of the machine, and the bearings ran perfectly free from heating or cutting. The efficiency of the machine must be very great, as, after its longest run of two hours, the armature was cool enough to handle with perfect comfort. The writer could bear his hand on every accessible part of the machine, which included all parts liable to any serious heating. The belt was new and stiff, and occasionally slipped as the limit of the power of the machine was approached; but that was a fault which a little work would cure, by making the belt flexible and giving it a better bearing on its pulleys. Had the engine driving it been of sufficient power, it was evident much more work could have been done than was actually performed on the trial. It was judged that it might have been driven up to 300,000 watts with safety. The conductors provided, and the resistance coil used in measuring the power developed, were, however, about at the limit of their endurance, as it was, the former heating until they were blue, and the latter requiring constant watching and cooling by application of water. The maximum reached was 249,000 watts, or 334 electrical horse-power, the engine probably

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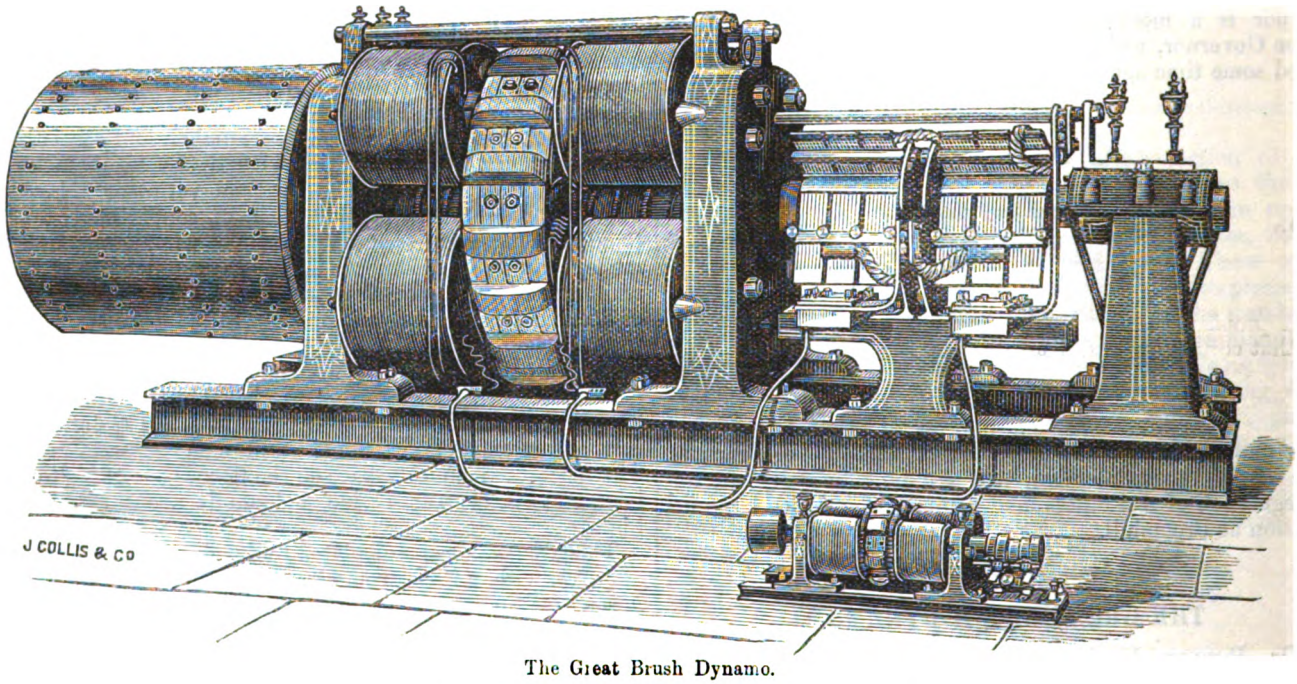
developing not far from 400 indicated horse-power. No indicators had been fitted, and it was impossible to measure this factor. The limit of its power was reached, however, and the power of the dynamo could not be tested to its maximum. The speed intended was, for the dynamo, 430 revolutions, but at eighty volts it could not be driven by the engine up to that speed.

The dynamo was built, complete, in all its details, from the specifications of Mr. Brush, and without preliminary experiment, and, when tested, was found to require no alterations of any kind, and came fully up to the requirements of the specifications and contract. Its capacity is very much greater than that of any machine yet built in the United States, or in the world. Its successful construction is considered by its designer to indicate that it is possible to design a machine of any desired size and power, with perfect confidence that it will come fully up to the calculated performance. No limit is to be seen, as yet, to the size and power of the machines, if properly designed. Their construction is a matter of definite calculation, and is to-day independent of direct experiment. The fact that a dynamo may be precisely designed and proportioned for any kind and amount of work that may be demanded, for any purpose whatever, without limit, so far as can be to-day perceived, is one of the most interesting and important revelations of recent work in in this field. The fact, also plainly shown by the experience of the Cowles Company, in the use of these enormous machines, that the larger the machine the higher the duty of the plant, is no less interesting and important. The economy secured in the production of their aluminum and other alloys, by the increased size of the later dynamos put in operation, is so great as to be a very valuable factor in the operation of the business, each new and larger machine very considerably reducing the price at which the metals can be put on the market.

The tabulated statement shown herewith presents the figures obtained at the trial of the ten-ton dynamo above described, and will repay careful study, as they exhibit the effect of variation of speed, of variation of current in the field shunt, and of electromotive force, in the production of energy in the external circuit. The highest power attained on this occasion was 249,000 watts, the speed of revolution being 405 (25 turns below the regular speed), the electromotive force being eighty-three volts (three above the standard), and the current measuring 3,200 amperes. The electromotive force in the shunt coils was eighty volts. The heaviest current measured 3,400 amperes, the electromotive force being sixty-eight in the main current and fifty-two in the shunt, the current energy measuring 231,000 watts at the terminals. At the standard speed of rotation, the circuit being broken, the measured electromotive force was 100 volts.

This remarkable and powerful machine was driven at the time of the visit of the writer to the works by a Corliss engine through a heavy counter shaft, the engine belt being carried over the belt from the jack shaft pulley to the machine. This arrangement is an unusual, but perfectly practicable one, and, in this case, worked admirably. It was occasionally necessary to readjust the position of the dynamo, as the belt, which was new and stiff and smooth, stretched more on one side than on the other; but this stretching will soon cease—probably has ceased—and, as the belt becomes more flexible and more perfectly fitted to its pulley, and as it takes its maximum stretch, it is evident that it will work with perfect accuracy, and will be competent to transmit any load that the dynamo can be expected to throw upon it.

The current from the machine to the furnace was conveyed by ropes of fine copper wire, or by conductors made up of several heavy wires. At the furnace they were connected to the terminals, which latter were of bar copper, apparently about two and one-fourth inches in diameter, armed with four carbons each, the latter of about the same diameter and four feet long. Between these was arranged the conducting material which furnished the incandescent bed in which the operation of reduction was carried on. This process is not, as is very often assumed, by professionals as well as non-professionals, an application of the voltaic arc to the production of high temperatures. Such an application was made by Sir William Siemens and by other experimenters from the time of the discovery of the intense heat of the arc; but it is, in the Cowles process, an application of the incandescent, as distinguished from the arc system. A connection is established between the carbon terminals, by means of a mass of carbon and other material, which mass is carefully kept continuous and incandescent throughout the whole operation. This is essential both to the success, actual and economical, of the process, and as distinguishing it from the older and wasteful systems of melting. By this system, the intense, the immeasurable heat of the arc is tempered and diffused throughout a large volume of incandescent material, and becomes adjustable and capable of regulation with comparative ease and exactness. Such control is thus secured as to make it convenient and economical in application to the reduction of ores and the melting of alloys and metals. Actual contact carries, everywhere, probably



The Great Brush Dynamo.

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a very large proportion of the current, and the heat is distributed among numberless little particles of highly-heated carbon, which lend each its share to the numberless particles of the compounds to be reduced.

Experiments with 42-in. Brush Machine. June 25, 1886.

Revolutions per Minute.	E.M.F. Volts in Ext. Circt.	Amperes in Ext. Circt.	Amperes in Field Shunt.	Watts in Ext. Circt.
428	78	1,000	33¼	78,000
424	68	2,000	30½	136,000
423	56	2,600	27½	140,000
420	66	2,600	37½	171,600
418	72	2,540	46½	190,080
410	76	2,700	58	205,200
420	94	2,040	89	191,760
412	88	2,450	85	215,600
405	83	3,200	80	249,000
423	56	2,700	29	151,200
423	62	3,400	45	210,800
423	68	3,400	52	231,260
423	52	3,000	33	156,000
421	46	2,950	28	135,700
421	36	2,620	21½	94,320
421	32	2,500	19	80,000
421	26	2,300	16	59,800
421	22	2,100	15	46,200
421	19	1,850	13	35,150
431	100	0,000	76	
431	105	0,000	100	

It is probably only by some such application of the electric heat that corundum can be made to surrender its aluminum to form an alloy with copper. It has been stated recently, in the discussion of this process, as described by Dr. Mehner, before the Association for the Advancement of Science in the kingdom of Prussia, at the Berlin meeting of the present year, that this reduction had been accomplished in a furnace heated in the ordinary manner; but it would seem that this must be a mistake, since alumina is one of the most refractory substances known in nature; it is said to be even more so than the materials of our furnaces and of our crucibles. The Messrs. Cowles have subjected it to the highest temperatures that a Dixon crucible would bear, without being able to reduce it or to melt it, in the presence of carbon and copper. Further, it would be probably impossible to successfully maintain a reducing flame, if that were attempted, or to avoid the reoxidisation of the metal were its reduction primarily possible. The reducing temperature of the compound is above the temperature of volatilisation, also, of the pure metal, and this would make it improbable that its reduction in this way should be successfully performed, far less with commercial success. The volatilised metal would rapidly escape from the Siemens furnace or from any other familiar form of furnace, while no other process than that above described would be capable of forming the volatilised metal in a closed furnace. In the Cowles furnace it is practicable to reduce alumina either with or without the presence of copper or other alloying metal, and one of the first intimations of the production of the working temperatures in that furnace is the appearance of fumes, indicating some volatilisation to be produced. As ordinarily conducted, this is not important in amount. Alloys of aluminum have been made in this furnace with nearly all familiar metals, a proof that copper, at least, is not essential to secure the reduction. So far as the writer has been informed, this is the only process by which reduction of this metal with carbon alone can be accomplished. The production of the metal commercially, in this manner, is expected to soon become an accomplished fact. The manufacture of the aluminum alloys has now for some time been successfully carried on, the cost of the aluminum in the alloy having been reduced to a small fraction of the price for which the metal is sold as made by the older methods. The Messrs. Cowles and Prof. Mabery have opened a new and broad field of experiment, and no one can surmise, even, what may come of the infinite range of possibilities so presented.

CORRESPONDENCE.

A PRACTICAL QUESTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have had my house lighted up for nearly two years with the electric light, supplied from Elwell-Parker's accumulators and dynamo driven by gas engine. Many of the lamps (16 candle) are now dull, and use 50 volts 38 amperes to give a good light. New ones give an equal light with 46 volts 32 amperes. Is it more economical to keep the old lamps in use longer and use more volts and amperes, or put new lamps and use less? The new lamps cost about 4s. each.

I shall be glad if you will kindly reply in your paper, so that others as well as myself may have the benefit of your opinion.—Yours, &c., S. A.

Manchester, October 11th, 1886.

[The following considerations will easily enable our correspondent to determine for himself which of the two courses is the more economical to pursue. From the data supplied it appears that with the old lamps the electrical horse-power consumed is equal to

$$\frac{50 \times 38}{746} = 2{\cdot}55 \text{ E.H.P.}$$

while with the new lamps he would get the same light by the expenditure of

$$\frac{46 \times 32}{746} = 1{\cdot}96 \text{ E.H.P.}$$

It therefore requires just one-half horse-power additional to run the old lamps, or 25 per cent. more than the total power required with new lamps. Our correspondent probably knows with sufficient accuracy how much a horse-power per annum is costing him. He also knows probably about how many lamps he has lost during the two years; he can therefore judge at what rate the charge for interest and depreciation upon the whole number of lamps should be estimated. Comparing this with the annual value of one-half horse-power he will at once see whether new lamps or extra power is the more expensive item. The calculation will not have any pretence to scientific accuracy, but it should be amply sufficient to answer the practical question. We have little doubt that he will find a considerable saving to be effected by renewing the lamps; but we shall be pleased to hear from our correspondent as to the conclusion at which he himself may arrive.—ED. *E.*]

ANTI-INDUCTION TELEPHONE CABLES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: We notice in your issue of 24th ult., in speaking of our anti-induction telephone cables, an error has occurred which might mislead if not corrected. In referring to the experiments conducted at our works, it is stated the cable had a capacity of 29 microfarads, which should be *0·29 microfarad per mile at 0°C.*—Yours, &c., FELTEN AND GUILLEAUME.

Mulheim-on-the-Rhine, 6th Oct., 1886.

ROYAL VISIT TO BURNLEY.—On the occasion of the visit of Prince Albert Victor to Burnley on Tuesday last we learn from a local journal that the town was brilliantly illuminated by electricity.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, *Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.*

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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LETTERS.

A letter awaits Mr. O. C. D. ROSS, M.I.C.E.

THE ELECTRICAL TRAMCAR.

Much hostility was aroused in this country when the earlier attempts were made to naturalise the American tramcar; chiefly, however, because of those preferential rights over the roadway which are indispensable to the tramcar's existence. That objection has gradually been condoned in the immense convenience which this method of locomotion has afforded the inhabitants of populous towns and cities; and for public conveyance between centre and suburb the tramcar is rapidly driving the omnibus off the road. One other objection, but of a quite different character, soon became manifest in the working of the system, namely, the exhausting effect on the horses. So serious is the expenditure under this head that the idea of working by steam locomotion soon took a practical shape, and in certain places where steam power was not unfamiliar in the streets the steam tram has actually invaded the precincts of the town. For suburban locomotion it is by no means uncommon, and where steep gradients have to be climbed, steam has been freely used, and without serious opposition, the general public arguing that only in this way can they enjoy the advantage of swift and smooth travelling.

Nevertheless, it cannot be denied that there is a very strong and a very natural prejudice against the steam tram. Its advent is immediately followed by the hoisting of signals of distress which are the sure indication that property in the neighbourhood is being depreciated. Residential thoroughfares are "to let" the instant any lines are laid for the accommodation of a steam tram; and although the convenience to passengers is the same whether horse or steam is the motive power, the devastation effected by the latter on house property is far worse than anything laid to the charge of the former. Nor can we wonder at it. If the makers of this hideous type of engine had deliberately designed the worst possible affront to a decent neighbourhood they could not have succeeded better. Whether they have consulted utility or economy most in the construction of what looks like a gigantic fish kettle with a stove pipe stuck on we are not in a position to say; but they have consulted nothing else. Even their own passengers are begrimed with soot, and sickened with the smell of burning oil. But passengers must put up with what they can get. Not so the inhabitants, past whose doors this frightful monster growls and pants, belching its grimy breath into their first floor windows, and who consequently hasten away to more secluded neighbourhoods, where the tyranny of vulgar utility is not so supreme.

There is something, too, about the steam tram which makes it an object of ridicule as well as of disgust. The absurd disproportion of means to end is obtrusively exemplified in the single car being sleepily dragged two or three miles by an engine which, judged by dimension, might speed a score of Pulmans to Birmingham at the rate of fifty miles an hour. Here, perhaps, the exigencies of frequent stoppages and startings, which tell upon the horses, prevail, even when the power is steam. Be that as it may, the steam car is a nuisance at best, and one which is not likely to be generally tolerated. Meanwhile, the waste of horseflesh on the ordinary tram-lines goes on apace, and proprietors are casting about for some motive power free from the objections we have enumerated. Some experiments on the North Metropolitan Tramway Company's lines at Manor Park last week point in this direction. Our readers are already familiar with the special gearing, which is the only peculiar feature of this system. We are inclined to think that the adoption of a separate locomotive car, though in itself a retrograde step, would have the practical merit of enabling every tramway company to give the electric system a trial, without having to make any change whatever in their present rolling stock. It is claimed for the Elieson system that a saving of 40 per cent. will be effected as compared with the cost of horses. Such claims are usually put forward; and all we need say about them is that we sincerely hope Mr. ELIESON'S methods will be subjected to a fair and practical test, we ourselves being perfectly satisfied that electrical propulsion has merits of its own which will commend it to favourable consideration apart from any such sanguine calculations as to saving in cost, though no doubt there is a saving.

One of its merits, over and above those we have already indicated, is that almost every one of the public objections to the laying down of tram lines would disappear were it known that they are to be worked by electrical power. The electrical tramcar is self-contained, perfectly clean, and rather handsome. The companies would effect an enormous gain on this account, if on no other. But so far as we have any trustworthy statistics to guide us, there is a real economy to be obtained by the construction and working of electrical tramways instead of horse or steam. Mr. HOLROYD SMITH, whose paper on the two mile electrical tram line at Blackpool was read at the British Association meeting, gave some very encouraging figures at the time, and some further details which we have published since go to confirm his estimate. For carrying 44,306 passengers over 2,760 miles during the week ended 10th September, the total working expenses were £45. 16s. 2d., the receipts being £347. 15s. 3d. Taking these figures on

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the basis of the capital expended in the construction of a very difficult line, under what may be called almost tentative and experimental conditions, there is every reason to regard them as satisfactory. Mr. VOLK'S experiment at Brighton, though on somewhat different principles, has been equally successful in proving the practicability of working a tram line by electrical means with perfect efficiency and the certainty of being remunerative. Our latest intelligence is that Mr. HOLROYD SMITH'S system has been put to a severe trial in the vicinity of Paris, where a number of eminent French engineers were present to witness it, and that their verdict was extremely gratifying to the promoter. On the whole we see good reason to anticipate that the question of tramway locomotion may soon be solved in a way at once satisfactory to the public and to the owners of existing tram lines.

THE SPRAGUE ELECTRIC RAILWAY SYSTEM.*

In December of last year a paper was read before the Society of Arts, Boston, by Mr. F. J. Sprague, on the subject of the application of electricity to the propulsion of motors on the elevated railroads of New York. This paper contained a thorough investigation of the power used and its distribution, and indicated some of the methods which the writer proposed to carry out in the system that he had devised. The Third-avenue Elevated Road was taken as an example. It was shown that on this road the work was expended in three different ways, viz.:—

1. In overcoming the inertia of the train, which was 59 per cent. of the total.
2. In lifting the train on up-grades, which amounted to 24 per cent.
3. In traction, 17 per cent.

It was pointed out that because of the great frequency of stoppages and the necessity of high speeds on this road, most of the energy of the train which was put into it on getting under way and lifting it on up-grades was of little value for traction. At the time this paper was written there were at commission hours sixty-three trains in operation at one time on the up and down tracks. This was on a double track line of only 8½ miles length. The aggregate power that the engines on this road were capable of exerting was nearly 11,700 horses, the engines being of about 185 horse-power capacity. The average power exerted during the time trains were in motion was 7,640 horses, or, for the entire time on a trip, including stoppages, about seventy-four horses for each train of four cars.

The problem of how to handle this tremendous power on grades running up as high as 105ft. to the mile, with trains stopping every third of a mile, and sometimes not half a station apart, and sometimes reaching a speed of twenty to twenty-two miles an hour, is no mean one. It is true that small roads have been operated, among them one six miles long at Portrush, Ireland; but the conditions are totally different, and the demands which would be made upon an electrical system by the conditions of service on the elevated railroads present a new problem, and this problem not alone an electrical but also a mechanical one.

The elevated system presents the results of a great many years of careful thought in engineering study. It is the culmination of a great many improvements. It has been carried to a degree of efficiency far higher than its most earnest supporter thought possible. It has been taxed to its uttermost. Recognising these difficulties, Mr. Sprague, backed by private enterprise, has been for a long time engaged in the elaboration of a system. Announcement was made some time ago that this system was under trial, and for some time past it has been in experimental operation on the north track of the Thirty-fourth street branch of the Manhattan Railroad. A full-sized standard passenger car was placed at his disposal by the officers of the Manhattan Company, and by this means a great many problems are being worked out.

* From the New York *Electrical World*, September 25th, 1886.

The great amount of power which is used on the elevated railroad and the distance over which the trains are handled necessitate in the electric circuit large currents of a high potential. The potential decided on was 600 volts, and the experiments on the Thirty-fourth street section have been carried on with that pressure. No such electrical potential has ever been used in practice for this particular class of work, and motors which might be used with small powers over short distances and with low potentials would not avail here.

As mentioned above, there are at one time 4,640 horse-power actually being developed. With an efficiency of 80 per cent. for the motors, this would mean a current of 7,215 amperes with 600 volts. The handling of a current of 7,215 amperes, and of from 600 to 665 volts electromotive force is a somewhat difficult matter. A conductor to carry this amount of energy without a very large loss under ordinary conditions must be large, but with the stations properly put in and with the rails properly reinforced, together with the methods of working, which will be described more in detail below, it will be seen that the difficulty of handling this has been very largely reduced. We will now enter into a somewhat technical description of this system, both with regard to what is being done and what will probably be done in the future.

The first subject to be considered is the generating station. The system preferred by Mr. Sprague is the operation of a number of dynamos wound so as to generate at their normal speed and with a full load an electromotive force of about 670 volts at their terminals. These dynamos are wound for constant potential circuits. They are of very low armature resistance, and have high resistance shunt fields. The dynamos may be built so as to maintain a constant potential under all loads at the junction of the mains with the track. There is one disadvantage, however, about this, and that is, if there should be any very serious cross on the line the machines might be burned out. Where they are wound with the field-magnets in a simple shunt circuit, and no cumulative coil in series with the armature, any very bad cross on a line will lower the potential at the terminals of the machines, and while a very heavy load will come upon them for a brief interval of time, the drop of potential at the terminals will be sufficient to so far demagnetise the field-magnets that the machines cannot be burnt out. In addition, however, to the ordinary shunt coil, Mr. Sprague employs a special winding, one which appears in his railroad motors. This special winding is a coil in series with the armature, whose polarity is exactly at right angles to the polarity set up by the shunt coils, and is so proportioned that it automatically maintains the point of non-sparking coincident with the line of contact with the brushes on the commutators. This series coil would not have the effect of an ordinary cumulative coil. It would not raise the potential of the dynamos, but simply makes them non-sparking with fixed brushes under all loads.

Considering the length of road and the amount of power used it would be better to have two central stations rather than one. The engines would be compound, condensing, and placed near the water. By this means the coal consumption could be reduced at the central station to as low as 2lb. of coal per indicated horse-power. By having two stations, each removed about a quarter of the distance of the length of the road from either end, the size of conductor which is necessary for the middle rail is only one-fourth that which would be required were there only one station in the middle. Furthermore, the points of supply of current from each station should be maintained at the same difference of potential, to obtain which Mr. Sprague runs an independent line wire from station to station, with suitable indicators in it, showing whenever there is any inequality of potential existing at the supply points. This is done because the highest possible economy requires perfectly equal differences of potential at all points of supply, no matter how many the trains nor where they may be situated on the track. The combined capacity of the two stations would be something more than equal to the highest total horse-power appearing at any one time on the road, which, as we have seen, is about 4,700 horse-power. It will be noted that there

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are no losses allowed for here. Why this is so will be explained in describing the system of braking which is used. This, then, would give a capacity at each station of about 2,500 horse-power. On account of the rise and fall of the work done on the line, it being light at night, somewhat heavier during the middle of the day, and at its maximum during the morning and evening, this 2,500 horse-power would be divided up into about four units, and to allow for any breakdown of an engine these units would be of about 800 horse-power each. The travel on the road is so perfectly known, and follows such a well-defined law of increase and decrease, that there would be no difficulty whatsoever in starting the engines at the proper time and throwing the dynamos into circuit.

We come now to the system of distribution, and this will be described more particularly with regard to the demands of the elevated railroads, leaving out particular reference to street roads, which form a department by themselves. There are many things which pertain to this system of distribution which would, of course, appertain to street work. The main rails are grounded, and form one side of the circuit, being connected to the structure of the road at suitable intervals. Four single rails, together with the superstructure and the ground connections, form a path of very low resistance. The other part of the circuit consists of a very light rail of special construction, thoroughly well insulated in a simple manner, and raised so that its top is from three to four inches above the plane of the ordinary traffic rails. This rail is not continuous, being of necessity broken at all switches, turn-outs, sidings, and cross-overs. The ends terminate about 18in. from all crossing traffic rails, and instead of ending abruptly, they are bent down slightly, so that when the collecting wheels, running on the central rail, leave or enter them, they do so without any shock or jar to the spring mechanism which carries them. This middle rail is further divided up into sections of any convenient length desired, say at intervals of 500 or 600ft.

In addition to this middle rail, there extends along the entire length of the line a heavy, continuous conductor, thoroughly insulated. This is connected to both ends of each section by fusible plugs or cut-outs and a short branch circuit. The branch circuits of the cut-outs form a Y connection, the main conductor being secured to the stem of the Y, and one end of each section to the arms of the Y. It will be seen now that in the normal condition of affairs if current is flowing from one part of the road to another part, and there is no train between these two parts, this current is carried over a double ladder-like circuit. The main conductor carries the major part of the current and the sectional working conductors a smaller part. So long as there is no train on the sections adjacent to any connection, it is evident that there is no difference of potential existing at the two opposite ends of the connecting branch, and no current will flow over it, although very powerful currents are flowing past each end of it. These currents will, of course, be in the same direction. When, however, a train enters a section it does not make any contact whatever with the main continuous conductors, but only with the working conductor, and current is supplied to this working conductor from both ends, partially, it may be, through the working conductors next adjacent, but mainly through the branches connecting it to the main conductor; that is, there is a difference of potential set up in the different parts of this circuit, and parts which were inert before become active the moment a train passes on to a section, no matter whether the train be taking current from the line or giving it to it. The current that flows through these branches may be made to actuate any kind of special device which is necessary, and thus forms a perfect block system of signalling, which operates by the presence of a train upon a section, since this train automatically sets signals at both ends of its section. These signals are of a variety of kinds, visual or audible, or both. Some are day and some night signals; and incandescent lamps, preferably two or more in multiple circuit with each other, are used for the night signals. Since the current on a motor is under perfect control, it follows that even if the train is at rest on the section the engineer is able to set his signals.

One of the great advantages of this system of main and working conductors is this:—If there is any bad cross or accident on the line the section will be cut out. The rest of the road will not be interfered with in the slightest, but the whole circuit will remain intact with the exception of the one particular branch of 500 or 600ft., which has been affected. The signals may be made of that automatic character such that when a cross does occur sufficient to break the safety catches of that particular section a signal is set and cannot be replaced until the section is repaired. We have here a perfect safeguard against any extended disabling of the line. Furthermore, if it becomes desirable at any time to operate a signal at only one end of the section the other end of the section can be cut out. If repairs are made, a section of the road being taken out or replaced, the track foreman can at once cut that particular section out of circuit, and after his repairs are made put it in again without interfering with the main line. In addition to these devices, the main working conductor can be divided up into sections and switches inserted, so that if it be desirable to cut out any extended portion of the track in case of any accident which makes the passage over a section of the track inadvisable, as in case of a fire, that portion can be cut out without the necessity of disconnecting each individual section.

In addition to these arrangements, the conductors of like potentials on different tracks and switches are connected by cross circuits which tend to equalise the potentials on the line, especially where there are any bad joints in the rail, and also when one track is more heavily loaded than the other. Another great advantage of these cross connections is that the current generated by trains running on down grades and stopping, can not only be sent back to the conductor on its own particular track and circulate through the system, but it can take a shorter and more direct path to the opposite track, where a train may be moving on the up grade or just starting. It should be further stated that both tracks are supplied from the same source, forming one complete circulating system. All motors are run in parallel circuit with each other, the current in each being independent of the current in all others, and the motors on the one track are in parallel circuit with the motors on the other.

We now come to the question of motor construction. The elevated railroad presents a special problem, as the strength of the superstructure is limited. At present the trains are drawn by locomotives which aggregate about twenty-two and a half tons in weight. Of this weight only fifteen tons is available for traction, this being the weight on the drivers. This weight of twenty-two and a half tons is centered in a very small space. Immediately behind the locomotive is the forward truck of a car, with a proportionate weight of nearly nine tons. There is then a total weight of over thirty-one tons in a space of about thirty-six feet, which is less than the distance between two columns. The consequence is that the strains, both tensile and shearing, are very great; but these strains are not the only source of danger. The vibration set up by a moving train, both vertical, due to the weight, and longitudinal, due to the motion of the train, has a shattering effect which is very great. It tends to loosen the bolts and badly strain the whole structure. There is an additional vibration due to the reciprocal strokes of the steam locomotive and its consequent unevenness of pull. If an electric locomotive were applied to handle a train, and it was made of 15 tons weight, it would pull more than a steam locomotive of equal weight, since all of it could be put upon the driving wheels, and there would be no necessity of additional truck wheels. But a fifteen-ton electric locomotive properly constructed and handled would pull even more than a twenty-two and a half ton steam locomotive with fifteen tons on its drivers. If the weight was distributed on four wheels, the wheels being on two perfectly independent axles, there would be absolutely equal pressure on each. This, however, is not the case with a steam locomotive. In addition to this, the strain could be simultaneously brought on all the wheels of an electric locomotive with such a perfect progression that they would adhere to the rail more firmly than an equal weight where the motion is derived from a reciprocal movement. Furthermore, there is a certain amount of increased adhesion of the wheels,

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just how much it is impossible to say, because it varies under different conditions, and this is probably due to the heating effect of the current passing from the rail into the wheel.

Another method of handling the cars, and this is the most logical, although it may be a somewhat more costly method of working when dealing with old rolling stock, is the placing of the motors underneath the cars on the trucks which carry them. In this way at least one-half of the weight of the car and the passengers, as well as the motors, is available for traction.

If the motors are thus placed under the cars, each can be made an independent unit, or a dozen cars can be operated

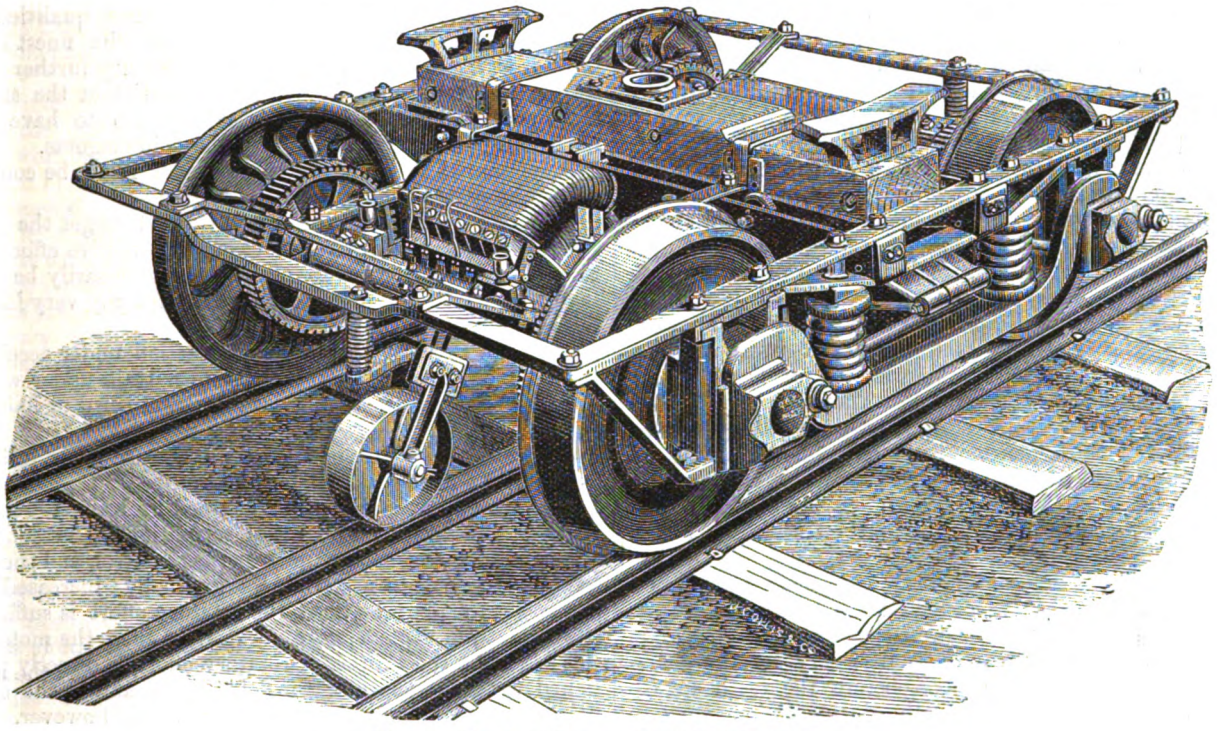

FIG. 1.—Truck of Sprague Electric Railway Car.

in a single train by a small regulating truck placed ahead of them.

This is the manner in which a single car is now being operated on the Thirty-fourth-street branch of the Third-avenue elevated railroad in New York City. The truck upon which the car is mounted is shown in perspective in Fig. 1, and in elevation in Fig. 2.

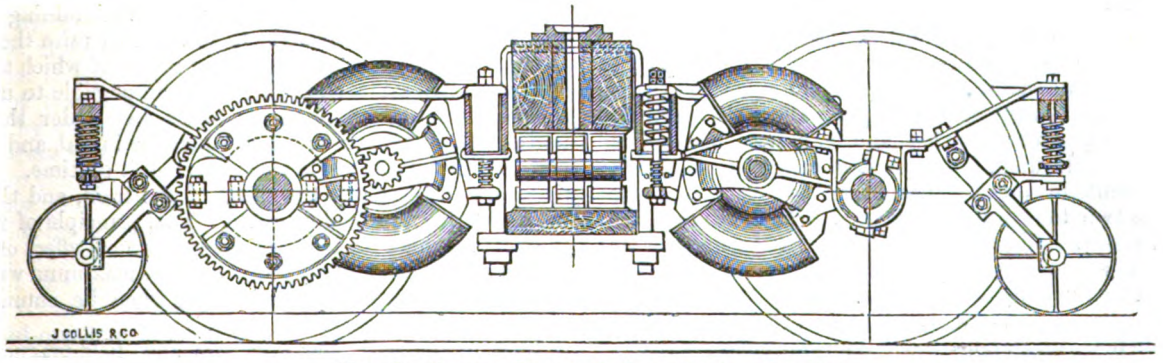

FIG. 2.—Sprague Electric Railway Truck—Elevation.

As will be seen, the latter represent a standard iron truck such as is in use on all the new cars of the elevated railroad, with, of course, some omissions and changes which were necessary for attaching the motors. The principal omission is that of all ordinary braking apparatus. There are two motors carried on this truck, each of the space between the axle and the centre cross-piece. The field-magnets, which are made of the finest selected scrap wrought iron, are built up of four segments, all forming parts of circles. Two of these form the pole pieces, and to these are attached heavy bronze hangers. The latter carry the armature, which is wound on a special modification of the Siemens system, and has at each end forged steel pinions of 3in. face and 3·7in. diameter on the pitch line. There are 13 teeth only. The hangers are extended and embrace the axle, which is turned off to a perfectly smooth surface, leaving a small shoulder at each side. Part of the hangers extending from the magnet pole pieces embrace one half of the axle, and the opposite half is embraced by heavy bronze caps, and inside each there are split liners to take up the wear. The armature shaft, as it passes through the hanger, is carried by two curved self-concentrating sleeves.

On the axles, close to the hub of the wheels on each side, are two split gears. These differ in character. One is keyed and bolted directly on to the axle, which is first turned off, and is a fixture. The other is composed of four parts, two being inner webs which are keyed on to the axle; the two outer ones form the geared section and are bolted together and have corresponding webs projecting inwardly, and fit snugly both on the outer edge and on the face of the webs which are keyed to the axle. The outer and inner webs are held together partially by the method in which they are turned up, but principally by bolts passing through them which work in curved slots. These, then, constitute adjustable split gears, and are probably a new thing in mechanics The gear wheels are of an especially fine grade of cast-iron, and are of the same face as the pinions which mesh into them. The number of teeth in these gears is 66; they are of the involute cut, so that if the motor should be moved to or from the axles slightly, the gears will still run perfectly true, with only a little more or less closeness of meshing. The pinions on the armature shaft

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are set so that the one is half a tooth in advance of the other. Ordinarily, it would be a very difficult matter to get the splines on both the armature shaft and the axle and in the pinion and gears, so that they would mesh smoothly when running forward and backward, and it was for the purpose of getting rid of this trouble that the adjustable split gear was designed. It is now only necessary to key the two pinions, one fixed gear, and the web of the other gear in position without any regard to their meshing. The motor is then swung into position, the hangers made to engage the axle, the caps are put on, and the motor being moved forward and backward two or three times while the bolts of the adjustable gear are slack, this gear will assume a perfectly correct position. The bolts are now tightened up, and there is thus a nest of double pinions and double gears all meshing with absolute precision, no matter whether the motor runs backward or forward. The method of mounting produces a concentric motion, and by this means the driving and the driven axles are maintained absolutely parallel in two planes under all circumstances.

To allow the motor freedom to follow all the movements of the independent axles over frogs and switches, and also for taking part of the weight of the motor off the body of the axles and to throw it on to the boxes, one end of the motor is suspended at its centre by a bolt passing through the cross girders. This bolt is adjustable, and the upper part is held by a very stiff spring in a state of compression, which spring is in turn supported by a wrought-iron saddle. The motor is then, so to speak, weighed or flexibly supported from the body of the truck. There is also a smaller spring to take up any back movement or tendency to lift of the motor. This suspension is directly in the centre of the pole piece, and the field magnets, which are grooved in the form of a circle, are independently detached from the pole pieces, one of them being put on after the motor is in place.

The operation of this mechanical movement or method of mounting motors has exceeded the expectations of its designer. Because of the relation between the teeth in the pinion and the split gear, it is necessary for the armature shaft to make 66 revolutions before the teeth engage in the same way, and each tooth of the pinion must in turn engage every tooth in the gears. It will be seen also, since the motor is suspended at one end by the truck axle and at the other by compression springs operating in both directions, that whenever the axle is in motion there is always a spring touch, so to speak, of the pinions upon the gears. Barring friction, a single pound of pressure exerted in either direction will lift or depress the motor a slight amount. It follows that, no matter how sudden a strain, nor how great, it is impossible to strip the gears unless the resultant strain is greater than that of the tensile strength of the iron ; because the moment that the motor exerts a pressure upon the gears, at the same instant do the spring supports allow the motor to rise or fall so as to give somewhat, and no matter how sudden the strain is brought upon the gears it is always a progressive one. The result in practice has been that with a weight equivalent to two tons upon each 30in. wheel these wheels have actually been skidded in continuous rotation upon a dry track, and the strain necessary to do this amounts to from 1,500 to 2,000 pounds upon each gear. Strain has also been put upon these gears as suddenly as it is possible to close a circuit across 600 volts, and without injurious effect.

This method of mounting motors tends to produce an absolutely perfect form of gear, and has practically obviated the noise which was at first anticipated.

Designs for motors of from 200 to 300 horse-power mounted on these same principles will soon be finished, and the motors constructed and put into operation.

We now come to the electrical features of the motor. The armatures shown in the drawing have a special modified form of Siemens winding. The shafts are built up of the finest forged steel, and the body of the armature is built up with alternating layers of tissue paper and very thin iron discs. The difficulties first experienced in dealing with currents of such high electromotive force and large volume have now been overcome. The bodies of the armatures are thoroughly japanned and baked, and the utmost precaution is taken in putting on the different coils of wire to insulate them both from the body of the armature and from each other by the use of a material which offers very high resistance to inductive discharges. The commutators are built of the finest copper, and no insulating material is used other than that just mentioned and fine selected mica.

One of the fundamental features of this system of electrical propulsion is to get rid of all adjustments and to reduce it to the simplest possible system of working and at the same time to maintain as high an efficiency as possible of the motors themselves. For this purpose it was necessary, because of the limited space available, to make the motors of light weight and yet capable of developing a very intense magnetic field. The form adopted for these motors has given these qualities. The motors themselves are built entirely of the finest selected scrap iron specially forged. It was necessary further to have a wide range of speed under full potential at the armature terminals, and hence it was necessary also to have a wide range in the magnetic intensity of the field-magnets.

A motor when acting in this manner is to be considered under three entirely different conditions :—

1. When it is at rest, and it is desired to get the greatest possible torque or tractive effort. This tractive effort should be under perfect control, and should necessarily be greater than that which the motor could exert for any very long continued time.

2. When exerting a continuous traction under accelerating speed. This is necessary in getting a train under way, and this effort ordinarily extends over the first third or half of its speed.

3. Variation in the speed of the armature after full potential has been reached at its terminals.

The first characteristic is obtained by bringing the field-magnets to a very high degree of saturation. Current is then admitted to the armature under perfect control, and the potential at the armature terminals gradually increased, thus increasing the current until the rotatory effort is sufficient to start the train from a state of rest. When the motor is in this condition the torque, or rotatory effort, is directly proportioned to the strength of the field-magnet and to the current flowing through the armature. As soon, however, as the armature starts to rotate a different condition exists. It is now necessary to exert a continuous traction ; but the motor, on account of its accelerating speed, is generating an increasing electromotive force of its own which is counter to that of the line, and the difference between this counter electromotive force and the line electromotive force determines the current through the armature. Consequently, it is necessary, while maintaining the field-magnet at the same strength, to still further raise the potential at the terminals of the armature by means of which the current is kept at the same strength. It is impossible to maintain a constant tractive effort in any other way under these conditions. The potential will soon equal the initial, and the motor will be doing its maximum work per unit of time. It is now necessary to accelerate the speed of the train, and this is done by weakening the field-magnets. This principle of weakening the field-magnets to increase the mechanical effect of a motor at all times when not working up to the maximum was brought out by Mr. Sprague some time ago, when he enunciated the following principle :—

In a motor with the armature and field-magnet independently supplied, the work which the motor will do in a given time, its economy and efficiency, are all independent of the strength of the field-magnet, provided the translating devices intermediate between the motor and whatever is the recipient of its energy are not limited as to the rate of transmission of the motor speed ; and that in all cases where a motor is working on a constant potential circuit and not up to its maximum capacity, in order to increase the mechanical effect either of speed or power or both, or to compensate for any falling off of the potential on a line, it is necessary to weaken the field-magnets, instead of strengthening them. The result is that, if running on a level at a certain speed and a grade is met, and it is desired to get up that grade at the same speed, it is necessary to weaken the field-magnets. If the potential falls

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off, and it is desired to keep up the same speed, it is necessary to weaken the field-magnets, and, conversely, if it is desired to slow down, it is necessary to strengthen the field-magnets.

A motor, when running, may be considered as a dynamo driven by a current. It generates an electromotive force dependent upon its resultant strength of field and the speed of the armature, and is independent of all other things. It follows that if the field-magnet be under proper control, this counter electromotive force is under perfect control under different speeds, and can be made greater or less in relation to the initial electromotive force, and consequently the motor can be made to do whatever work is desired of it.

This system of handling a motor, which is an essential departure from previous methods, has been carried out to its logical conclusion in braking the train, as will be indicated later.

The winding of the field-magnets of the motors is peculiar. One of the great difficulties which has invariably been met with in working with motors is the change of lead necessary to get the brushes at the point of non-sparking. It is absolutely necessary when dealing with large powers, if there is going to be continuous and successful running, to maintain the brushes at such a point. This change of the lead is caused by a distortion which is set up by the armature, varies with every change of load, with every change of armature current, and with every change in the field-magnet strength. It has furthermore been the habit where any considerable power has been developed to use two sets of brushes, one for forward and the other for backward motion. Mr. Sprague has entirely obviated the necessity for doing this by an arrangement which is as simple as it is efficient. This consists in the method of constructing, winding, and connecting up the field-magnets. The latter are wound with two sets of coils. One of these is a fine shunt coil, which is in series with an independent regulating resistance, and produces the normal poles; the other is a coarse coil in series with the armature which tends to produce poles at right angles to the normal poles, and this circuit is included in the reversing switch, so that when the armature circuit is reversed the current in the coarse coil is also reversed. There are then four poles set up in this machine, two being normal and variable at will, the other two being abnormal variable poles dependent upon the current flowing through the armature.

In the normal arrangement of circuits, the two sets of field coils, fine and coarse, combine to set up a resultant polar line which is distorted or rotated in the plane of rotation of the armature. Since any increase in the armature current causes the same increase in the series field coils, the tendency to distortion by these two elements will always vary to the same extent, and the resultant position will be always the same no matter what is the extent of variation of current. If the strength of the field-magnet is varied independently of the armature, by changing the resistance in the shunt field circuit or by a variation of potential on the line, while there is a tendency to change the armature distortion, there is an equal and opposite tendency to change the distortion due to the series field coils, and so this, also, has no effect. If the direction of the armature current is changed, so also is that of the current in the series field, and hence the direction of each distortion is changed; but they still oppose each other and vary equally and oppositely as before, and there is still no change in the non-sparking points. It is immaterial whether the change in direction of armature current is due to a change of terminals in changing the direction of rotation of the motor, or is caused in changing the motor into a generator by strengthening the field. Hence, the motor will run in either direction on a circuit of constant or varying potential, with a single or double set of tangential or end-contact brushes, with no change of lead, and, consequently, with no necessity for changing the position of the brushes. The position of the brushes having been once properly adjusted, it is made independent of the amount of work the machine is doing, or the speed at which it runs, or whether it is acting as a dynamo or as a motor. It is likewise independent of the strength of field and of the armature current so long as the magnetic moment of the field sufficiently exceeds that of the armature.

At each end of the car there are three vertical switch rods, connected by movable links with rods running through from one end of the car to the other. These rods have projecting fingers which operate the levers of three very rapidly-moving switches; the movement of these switches is independent of the rapidity of movement of the hand, which simply stores up energy until a certain point is reached, when the lever is freed, and the switch thrown over automatically. These three switches are employed as follows:—One for breaking the main circuit, another for reversing the armature circuit, and a third for detaching the armature partially from the line and closing it upon a local regulating apparatus. The movement of the handles on the vertical rods are similar at each end. Forward motion of one means forward movement of the car; forward movement of another means closing the main circuit, and a forward movement of the third means also a throwing off of the brake circuit. So that when a man stands at either end of the car, precisely the same movements mean the same thing as he looks up the track. In addition to these three vertical rods, there is a fourth rod which connects by a bevelled gear with a rod running through underneath the car, and provided with universal joints so as to allow of any necessary adjustment. The top of this rod carries a wheel very much like a brake wheel, and it connects with a regulator which consists of a series of resistance coils. These are so arranged that by the continuous movement of the regulator handle they are first cut out of the armature circuit, while the field is maintained at a high saturation, thereby raising the armature potential, and then cut into the field circuit in reverse manner, thereby weakening the field. This regulator governs also both steps of braking the train.

The current is taken from the centre rail by three conductors, two of which are bronze wheels working on pivoted arms under compression springs. They are provided with adjustable nuts to regulate the tension, and lock nuts to prevent the wheels dropping more than a certain limited amount when leaving the middle rail. The arrangement of contacts is such that the car will span 30ft. spaces without breaking the circuit. The other part of the circuit comes through the wheels of the truck, so that one part of the apparatus is continually grounded. The collector and the main circuits both run to fusible cut-outs before they reach the main braking circuit, and the armatures are also independently supplied at both ends with similar cut-outs. The armatures and the field-magnets are all in parallel circuit with each other.

This is the first instance in which two independent motors have been simultaneously controlled from the same regulating source, and by the methods employed it is perfectly possible to control 20 motors in the same way. When it is considered that the speeds vary from zero to 1,200 revolutions a minute, and the speeds of the two motors should be same, it will be seen how important a step has been taken. The torque or rotary effort of these motors under slow speeds is very great, and they are able to start from rest and propel two full-sized cars up the maximum grade on the elevated railroad. The motors weigh about 1,200lbs. each.

We come now to the system of braking, which is the logical sequence of the system of controlling motors originated by Mr. Sprague. As is well known, when a motor is in operation it is generating an electromotive force. In other words, it is acting like a dynamo, and since this depends upon the strength of the field-magnet and the speed, and since the field-magnet strength is under positive control, it follows that this motor electromotive force can be made to equal the initial motive force and even to exceed it. When this electromotive force of the motor thus predominates, the machine will become a generator and give current to the line, and its mechanical effects are reversed so that it brakes the train instead of propelling it; and the current generated by it, and the braking power, or reversed mechanical effect, are now controllable by further increasing or re-diminishing the strength of the field, and the new dynamo can now be changed back into a motor instantly at will. The mechanical energy received by the reversed motor and delivered as electricity to the line depends upon the mass of the train and its velocity. In running on a down grade there would naturally be an acceleration of speed, but this method of braking can limit that accelera-

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tion at any desired point, or the motor can be slowed down when running on the down grade. This is done, of course, by strengthening the field-magnets. Since the energy of the train is now being used to run the motors as braking dynamos, the train will be run at a certain constant speed down grade ; or if the field-magnets be still further strengthened, the train will slow down ; this occurs also in the ordinary process of stopping. The diminution of speed, however, reduces again this motor electromotive force, and hence the field-magnet has to be strengthened still further as a train slows, until the speed is reached which, with the strongest field-magnet, will give a motor electromotive force equal to that of the line. This point with the motors in question is at about one-third speed, or seven miles an hour. Hence, eight-ninths of the energy of a train moving 21 miles an hour is sent back to the line in current to relieve the generating station. In fact, the system as here set out has the advantages of a cable road, together with other advantages which the cable road does not possess, because not only do the trains running on down grades help the trains running on up grades, but those which are slowing down likewise give up their energy to the system. In fact, this system is one in which trains slowing down and running on down grades supply the current for trains running on up grades and starting, and the central station becomes a differential factor to make up for the loss of conversion and reconversion and to provide for traction and loss in the conductors.

Were the machines perfect converters of energy, this would make the power taken by a system almost independent of grades and stops, and would simply be that necessary to provide for continuous traction and for loss on conductors. Of course, this perfection of conversion can never be reached. It does, however, make a difference of 40 per cent. in the power required to operate the electric railroads at the central stations, in the losses on conductors of a given size, and in the investment necessary in the central stations. As a matter of fact, there would be required at the central station only such horse-power as is to-day actually developed at any one moment on the elevated railroads, which is only about two-fifths of the capacity of the motors or engines.

Hence, instead of 7,215 amperes of current being supplied from the central stations at two points, it is supplied from as many additional moving stations as there are trains being checked on a down grade and stopping. Sixty per cent. only of this current would come from the main station ; that is, 4,329 amperes, or 2,165 from each.

The final step of braking is done by partially detaching the armature from the main line when its motor electromotive force is equal to that of the initial, at which moment there is no current flowing through it, and closing it upon the same local regulating apparatus which is used for regulating the speed and power, and the first step of braking. By this means the train can be brought to a full stop. All these steps of braking are under the most perfect control, but if necessary the breaking can be so sudden as to cause the wheels to have a continuous skidding rotation ; not such a skidding as is caused when an air brake is put on too hard, but a rotating slip which will be just enough to relieve the armature when the strain on it has come to a certain point. This is the most perfect possible method of braking, because fixed skidding is an impossibility, and the wheels will turn until the train comes to a dead stop, although where the braking power is put on too suddenly and exceeds the grip of the wheels, they will relieve themselves by slipping just enough to keep the braking at the maximum limit. With the switch in position for the last step of braking, the car can be allowed to creep down the maximum grades at a snail's pace with a movement so slow as to be almost imperceptible.

It is the customary practice to stop at the Second-avenue station of the elevated railroad station, which is on a 95-foot grade, without the use of any shoe brakes, although the rear truck is fitted with these and can be operated at either end of the car.

By a slight reversal of the armature effort, the car will stand at a dead rest on this grade. The energy of the train which is expended in the last step of braking can be used in heating the car, and some interesting experiments are now being carried on at the Thirty-fourth street station.

It should be noted that at present the generating station for this experiment is situated on Twenty-fourth street, so that the current at times is carried about three-fourths of a mile. The proper electromotive force is obtained by coupling together five Edison machines in series. The wire used is No. 1 B.W.G., and is carried on the Western Union Telegraph poles. Mr. Sprague has by no means rested satisfied in developing his system of railway and carrying it to the advanced condition in which it now is, but he is now engaged in equipping the station and cars along the line of the road with Edison lamps, which are run in series from the same high constant potential circuit that supplies the car, on a system which has been developed by Mr. E. H. Johnson, the president of the company. A *résumé* of the special and distinctive features of Mr. Sprague's system may not be uninteresting, and is therefore given below :—A double-track system with motors working in parallel circuit with each other on a constant potential circuit, the two tracks being supplied from the same source and from the same main conductors. A supply at two or more points by independent automatically non-sparking machines, the points of supply being maintained at the same differences of potential. A system of continuous main conductors intersected by switches, and sectional working conductors connected therewith through automatic safety devices. Means for cutting out, either automatically, in case of accident, or at will, if desired, any portion of the circuit. An automatic block signal system for day and night use. Methods for the equalisation of potential by cross connections between conductors of like polarity and on different tracks. A very simple construction of the motor proper. The centering of the motor upon the axles so as to maintain parallelism between the driving shaft and the driven axle.

The method of flexibly supporting a part of the weight of the motor from the truck, so as to allow perfect freedom in following the motions of the independent axles. The method of doing away with all shock and jar and danger of stripping the gears, and the maintaining at all times of a spring touch so as to prevent any backlash and to insure quiet running. Double driving from opposite ends of the motor shaft. The use of fixed and adjustable split gears. The means for getting a very intense rotary effort in starting by having an intense magnetic field and raising the armature potential gradually. The means for maintaining a continuous and equal traction until full potential has been reached. The method of increasing or decreasing the mechanical effects, whether of speed or power, or both, by an inverse varying of the field-magnet strength. The method of controlling two or more independent motors simultaneously from the same source and by the same apparatus.

MILLER'S PORTABLE TORSION MAGNETOMETER.*

BY PROF. BLYTH.

The armature is formed of five small bars *of soft iron* 5mm. long and weighing one gramme. The index wheel has its rim divided into $\frac{1}{100}$ths, and carries the outer end of a flat spiral spring, the inner end of which is firmly fixed to the long axis which carries the small armature bars. A fixed pointer projects from the ends of the case across the edge of the disc, and another pointer is fixed to the armature axis. In the normal position the pointers both point to the zero of the scale. When the armatures are placed in a magnetic field they are turned round and brought back to their zero position by coiling the spring through a definite angle depending upon the strength of the field. A constant is determined for the instrument by experiments in a field of known strength, or, if necessary, it can be empirically guaranteed. It is hoped that the instrument will be found of service to makers of dynamos for finding the strength of the field in various parts, and also for finding the best forms of pole pieces. There is also exhibited a form of small attraction magnetometer.

* Paper read before the British Association at Birmingham.

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COMPARISON OF HARCOURT AND METHVEN PHOTOMETRIC STANDARDS.*

Perhaps no subject has received greater attention during the last few years than that of light and lighting in general. Public and private lighting have received an impetus which is gaining in strength every day.

The competition of the electric light has done an enormous amount of good in opening the eyes of the public to the defects of the old methods and the necessity for new.

Where a few years ago we could have found only a few persons who had any practical knowledge of photometry we now find hundreds. We have boys and girls making accurate photometrical tests by hundreds every day in the manufactories of glow lamps. We have the leading scientific men of the day devoting themselves to the comparison and analysis of all kinds and quantities of light, and yet when we are asked by what standard is light measured, and what is the meaning of a candle-power, how completely unsatisfactory is the answer.

It is true that many text books give full particulars of the various standards of light, and the relative values which the standards in different countries bear to one another; but who is there bold enough to assert that an expert in Berlin will give the same value to a particular light as one in Paris or London?

And this unsatisfactory state of things is not due, as many think, to the fact that A's eyes are not the same as B's, for if the two meet for the purpose of comparison they probably find that their personal error is an extremely small quantity.

But we may confidently assert that the variations are mainly due to the absence of the necessary standard, which in the case of weight, length, time, and heat is irrevocably fixed.

Science has not been idle in its attempts to settle the question, and many are the methods proposed as a solution of the difficulty, some feasible, others eminently impracticable; but Government authorities alone can settle the question for each country, and to them we naturally look for information.

And here we are immediately brought face to face with the anomalous state of things that the Government standard, as at present fixed, is absolutely the last which any experienced person would adopt except under legal compulsion, and instead of it we find various standards recommended and adopted according to the requirements of the work to be done.

Having been for a considerable time engaged in the measurement of the light of glow lamps and other sources of light at the factory of Messrs. Woodhouse and Rawson, at Hammersmith, in London, it has been of the utmost importance for us to procure a perfectly reliable standard by which we may determine the correct electomotive force which should be supplied to the various types of glow lamps made by us to produce the normal candle-power at which the lamps are intended to be used.

It may, perhaps, be of interest to those of you here present who are technically acquainted with the subject, and also to others, if I put shortly before you our experience of two of the standards at present employed in work of this kind. The result of a committee appointed by the Board of Trade in 1881 to report upon photometric standards was to bring prominently into notice two standards, viz., the Harcourt air gas lamp and the Methven screen. These two I have here on the table, and it is with regard to them that I wish to speak to-day.

Description of Methven screen and improvements made in the Harcourt lamp since last meeting of the British Association.—Having both standards in our possession it was naturally a matter of some interest to compare the two, and a considerable time ago we made a rough comparison of them, but about eight months ago my colleague, Mr. W. F. Donkin, and I commenced a series of experiments to determine the exact comparative value of the two, and to find the extent and probable cause of the variations observable in the Methven screen.

The report of the above-mentioned committee on photometric standards stated with regard to this standard that "where there is not any liability to a greater alteration in the quality of the coal gas than about two candles, the ease and rapidity of this system may render it extremely useful in determining the illuminating power of gas" (or other sources of light), "but the lamp in its present form has not that exactness for such a range as is necessary for a standard of light." In other words, the report stated that this was a fair commercial standard for employment in places such as London, where the normal variation of the value of the gas does not exceed two or three candles. As there was at that time a great demand for such a commodity, owing to the great inaccuracies of measurements by standard candles (which errors are very well set forth in the above report), the Methven screen was taken up as a distinct advance upon the time-honoured "parliamentary candle," and rapidly came into general use.

Since then it has found its way largely to America and the Continent, and, we believe, has lately been supplied to the Canadian Government.

In its original form the standard was so constructed that the centre support was in a vertical line with the screen, and from this point all measurements of distance were made.

The instructions now issued with the standard state that "the measurements are to be made from the centre of the burner, which position in a 60in. Letheby photometer is 30in. from the centre of the graduated bar."

Now, these instructions certainly lead to the conclusion that the standard is fitted for employment in a Letheby photometer, and as ours is of that pattern we should expect to obtain good results with it. Our earlier experiments were made with a bar of 80in. length; but, as we wished to work at greater distances, we had a new photometer constructed with a bar of 144in., in which great care was taken to verify all measurements. In addition to the ordinary bar graduated in candle-powers, we have a brass bar divided into tenths of an inch, which enables us to take readings by estimation to one hundredth of an inch.

At first the Methven screen was fixed at the right hand end of the bar, and the Harcourt lamp was mounted upon a carriage which moved in the same grooves as the disc holder. In our later experiments these positions have been reversed.

The position of each was very carefully determined at the commencement of each test, and the chimneys were scrupulously cleaned—an important point too often overlooked. The table is so marked that the carriage can be placed at any required point with great exactness. The distance between centres which we usually have employed are multiples of 10in. from 20in. to 120in. It was only necessary, therefore, to place one standard at any required distance from the other, and then take a series of readings, from the mean of which we could calculate the value of one in terms of the other. We have always taken the value of the Methven in terms of the Harcourt as unity.

Both standards were carefully watched by one observer, through blue glass, while the other took his readings; by this we guarded against any change taking place in the heights of the flames, and causing an error in the readings. The constant flickering of the flame in the Methven standard makes it difficult to determine accurately when the flame is at the right height, and this may constitute a source of error, as we have found a change taking place in the quantity of gas passing, and consequently in the value of the light when the eye was hardly able to detect a change in the height of the flame.

At first we worked with a Harcourt lamp without a chimney, and we were obliged to be very careful to exclude draughts, as the height could not be accurately determined unless the flame were steady, but latterly we have used the form which you see here, and the flame of this is absolutely steady, and no difficulty arises on this ground. The earlier values found for the Methven were so far below what is given as its normal value, viz., two candles, that we sent our screen to the makers, asking them to verify its correctness, and it was returned to us with the value of 1·98, or 1 per cent. below normal.

At the same time we verified the accuracy of the Harcourt by comparison with the official standard at the gas referee's office, and it was found to be correct within the limits of skilled observation.

* Paper read before the British Association at Birmingham by W. Stepney Rawson.

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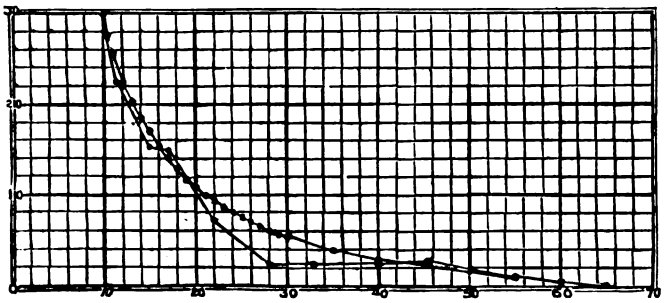
I may state that the standard had been carefully compared two years previously with Mr. Harcourt's standard at Oxford, and had been found by him to be correct. Now, I think you will not have much difficulty in seeing that with this form of the Methven standard as the disc recedes from the screen the light falling on the former will gradually decrease, from a cause different from that known as the decrease according to the law of the inverse square of the distance.

To explain this I would ask you to think of the case of looking through a casemate or loophole at the country beyond. As you come nearer to the opening more and more of the landscape appears, while if you recede from it the view contracts gradually till at last a further movement makes little or no difference to the amount seen through the opening. The disc then represents the observer's eye, and the luminous flame is in place of the country seen beyond.

This objection applies equally to all standards which employ what is known as the slot method, unless the slot is so close to the plane as to be practically touching it or the measurements of the distance are made from the slot.

It may be shown mathematically that the diminution of light due to this cause does not depend upon the size of the slot, but only upon the distance of the slot from the flame, whereas, if measurements are made from the slot and the light behind can be regarded as a flat homogeneous flame, the law of inverse squares holds as rigidly as with a naked flame.



Theoretical Curve of Variation of Methven Standard.

The above diagram shows the theoretical curve of variation determined from the measured distance in our standard of 1·4in., between the slot and the centre of the flame, which may be regarded as the mean position of the luminous source. I have also marked the mean curve deducted from a number of observations made by Mr. Donkin and myself. In order to show the curve more plainly, I have taken for abscissæ the distances of the Methven from the disc, and for ordinates the rise per cent. of its value above that which it has at 65in. from the disc.

The curve is the mean of values observed between February and April of this year, and though by no means perfectly agreeing with the theoretical curve in some places, yet the discrepancies are small, in no case being more than 3½ per cent. and in some cases less than 1 per cent. The curve shows, I think, that a considerable rise, amounting in one place to 25 per cent., takes place in the value of the Methven as the disc approaches it.

On one occasion we investigated the point as to whether the light is absolutely constant, even when measurements are made from the slot. We found, as others also have, that a slight increase takes place as the disc approaches, due to the greater thickness of flame subtended by the disc. The values on each occasion were taken with the wire of the Harcourt, set at 2½in., and the proper reduction made according to the formula established by Mr. Harcourt for changes due to alteration of barometrical pressure.

In order to satisfy ourselves still further as to the nature of the variation at different distances we employed the following method :—An incandescent lamp was made with two filaments, so that either could be run separately or both at once either in parallel or in series. These were made of different sizes, so as to give three different amounts of light according as one or the other or both were run.

If a perfectly constant E.M.F. be maintained at the terminals of the lamp, the light emitted by the two filaments together should be the sum of the lights of each observed separately. But it will be plain that if the above variations exist, the observed sum, when using the Methven as the unit of light, will be less than the true sum, because the value of the Methven is greater at the shorter distance of the disc from it.

We found, as was to be expected, that this was always the case ; but we made a more rigorous test of the accuracy of the theoretical values by taking the theoretical values for the longer distances corresponding to the values of the lights from the filaments observed separately, and then deducing from the observed sum the real value of the Methven at the distance corresponding to the sum of the lights. This value should of course be the same as the theoretical value at that distance. By properly choosing the E.M.F. this method could be employed to establish the variation over the whole range of the bar.

In order to keep the E.M.F. perfectly constant secondary batteries were employed, and any minute variations noted by a Thomson voltmeter, and corrected by an adjustable resistance in circuit. A delicate ammeter in circuit was also used to check the accuracy of the current passing when both filaments were run, being equal to the sum of the currents observed with each filament separately. The result of three carefully made series of tests gave us a mean deviation from the theoretical curve of less than one per cent. The lamp was so arranged that it was not moved during the tests, and the contacts were all made by mercury cups, except at the terminals of the lamp, which were carefully cleaned and clamped by broad pieces of metal.

I have quite recently made a fresh determination of our earlier results, as I found that the disc we had employed had become slightly tinged with yellow by atmospheric action, which would give us results slightly in favour of the yellower of the two lights. These determinations have been made nearly continuously during the month of August, and I have unfortunately been deprived of the assistance of Mr. Donkin, who has been absent during the time, though I have generally had the help of a qualified person in determining the setting of the distances and other details. A change in the construction of the photometer necessitated a reversal of the positions of the standards, the Harcourt now being at the right-hand end of the bar and the Methven mounted upon the movable carriage.

The results at first were manifestly incorrect, and I soon found that this was due to reflected light from the large body of light in the Argand flame, which, in spite of black curtains for sides and back ground, threw sufficient extra light upon the disc to render the results plainly wrong. In our earlier experiments this was prevented by a large fixed screen in front of the Methven slot. The difficulty was easily cured by placing perforated screens between the disc and both standards, allowing only direct rays to fall upon the disc. In spite of this I was unable to obtain results over the whole scale at all comparable in uniformity with our previous readings.

The value of the Methven was far lower than could be accounted for by the change of disc, and it was impossible to obtain concordant results extending over a period of four or five hours. Portions of the readings would be fairly correct, and then a deviation would take place from the theoretical curve, and on returning to a previously tested position a change would be found to have taken place. I therefore obtained a meter of the well-known makers, Sugg and Co., in order to test the quantity of gas passing with a 3in. flame, and also the total light given by the flame with the normal 5ft. of gas. I found, to my surprise, that 5·8ft. were required to produce a 3in. flame—this is 16 per cent. in excess of the normal—also the total light of this flame was on August 2nd only 15 candles, whereas it should be 16 candles with 5ft.

But on August 28th, at 4:30 p.m., I tested the amount of light with a 3in. flame consuming 6ft. of gas, and also with 5ft. of gas passing. I found the former only 13·2 candles, and the latter 9·2, instead of the normal 16. This probably was the cause of the inaccuracies in my later readings, for though the Methven is practically constant for small variations of quality of gas above and below the normal, yet when the quality is so far below normal as I found it it seems to be

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remarkably sensitive to small variations in quality, such as are constantly occurring in the evening. I can only suppose that in the winter months we were more fortunate in obtaining gas of a tolerably constant quality during our experiments, although from the low value of the Methven I think it must have been considerably below normal.

I have been informed that deposition of heavy hydrocarbons in the service pipes causes a serious diminution in the quality of gas reaching a consumer, especially if he, like myself, has the misfortune to be at the far end of a long service pipe, and something like four miles from the gas works, so that I can hardly suppose that a sample of gas taken straight from our main in the Hammersmith-road would produce such poor results; but, however that may be, we have obtained exactly the conditions in which the committee foresaw so much danger in a standard founded upon the consumption of gas which is subject to considerable variation.

I think that I have sufficiently pointed out the difficulties we have encountered with this standard, and I have only to add that in its present form it is obviously faulty; and even if it were altered back to its old form, and measurements made from the slot, it would be still unreliable unless a constant check could be kept upon the quality of gas passing through it, and allowance would always have to be made for the variation due to increased thickness of flame, as mentioned before.

I am only expressing the opinion of nearly all those who have any acquaintance with the Harcourt lamp when I say that a three years' experience of it as it has developed its practicability and handiness, and increased its accuracy by the employment of a reduction table for barometrical changes, enables me to say, with perfect confidence, that though, perhaps, it may not be the ideal standard of white light of which we are in search, yet it is a unit of light which is practical in construction and adjustment, and as regards its extreme accuracy is well worthy to be classified as a recognised standard unit.

THE NATIONAL ELECTRIC LIGHT ASSOCIATION OF THE UNITED STATES.

(Continued from page 460.)

Among the remaining subjects which came before the Association were several whose interest was rather of a national than of a general character. For instance, a paper was read protesting against the enforcement of electrical subways; another on the United States Patent and Common Law, as affecting the various electrical interests, particularly with regard to the question of the interference of the electric light conductors with telegraph and telephone work. A third paper on "wire joints," although treating the subject in a sound and able manner, can scarcely be said to have had more than a local interest. It dealt mainly with the necessity for making all joints with scrupulous care, above all things avoiding a mere twist; but as we really think that, as a class, the electrical engineers of this country at least have already mastered the A B C of their profession, we forbear to reproduce the essay. The last paper of importance was the following:—

Carbons for Incandescent Lighting.

BY MR. A. S. HICKLEY.

It is not my object in this paper to enter into a lengthy description of carbons of various makes or to criticise what others are doing in that branch of electrical industry, but to offer a few remarks especially connected with the manufacture and testing of carbons, as far as I have been connected with the production of the same. A long-lived lamp is not always an efficient one; you may have a lamp that lives 1,000 hours, but costs you too much to run. Better have one which lives only half that time, but which remains clear, or comparatively so, to the end, and requires one-third the power to run it. Of course, the consumers want both qualities, longevity and efficiency. With a view of meeting these requirements, I commenced a series of experiments with carbon of every conceivable description of material and compound I could obtain. It is not necessary to refer back to the many disappointments and failures of first experiences, for we all have been through that more or less. Suffice it to say, it soon became apparent that, as a general rule, an efficient carbon was not a long-lived one, and *vice versa*.

The question then arose: Why is that so? and after many experiments, both in baking, preparing and treating, exhausting with and without gases within the globe, I gathered some facts which I have the honour of bringing before you to-day. I soon discovered what is now a recognised fact, that after reaching a certain point of incandescence the candle-power doubled up with the increase of a very few volts. A 16 candle-power carbon at 100 volts, made of a certain material, became 32 candle-power upon the potential at its terminals being increased to 120 volts; again, the E.M.F. falling to 95 volts reduced the candle-power to 10. The size of the carbon had little to do with this in many cases. Thus a carbon of a certain size and 6in. long, took 8 amperes with an E.M.F. of 100 volts to produce a 16 candle-power light; another of the same diameter and length took 4 amperes and 100 volts to produce the same light. But let us watch them burn; at the end of 100 hours the 8 ampere lamp was becoming dark upon the inside, the 4 ampere one remaining as clear as when new; at 500 hours the 8 ampere lamp was so black that the carbon could be seen only when burning, and gave a light externally of but 6 candles. The 4 ampere lamp still remained clear, but burnt out at 550 hours, and had given not less than 15 candle-power until the end. Upon breaking the 8 amp. lamp the carbon was found to be roughened all over, the roughness being evidently caused by small particles of carbon being thrown off, these particles not only causing the carbon to increase in resistance by their separation from the main carbon, but carbonising the interior of the globe as mentioned before.

Carbons of the same material but of different diameter were then tested, all, I may say, being carefully examined before and after the tests through a powerful microscope. Two carbons were tested, each one being 100 volts, but one being twice as thick as the other. The thicker one gave a 16 candle-power light with the consumption of energy equal to 70 watts. The thinner one gave 40 candle-power with the same power, but the latter soon burnt out, and upon microscopic examination it was found that the fibres were cracked all over, and were bent at right angles to the grain of the material, and sticking out, as it were, towards the glass. I tried this upon a large scale, and made a carbon as large as a No. 13 wire. It behaved precisely the same, but now the fibres were quite visible to the naked eye and stood out all over the filament as though it had become indignant at being abused and roughened, its coat resembling an electrified cat or a porcupine. With this carbon I could produce a light equal to a candle for every watt, with lamps of 50 candle-power, but it would show fight and throw off his jacket. This was overcome at last in a manner I will explain later.

A carbon composed principally of the mushrooms formed between some arc-lamp carbons, forced through a small hole under great pressure, threw off some particles as soon as they were rendered sufficiently incandescent to be efficient. Structureless filaments behaved the same way, especially when not treated in a hydro-carbon. Much depends upon the manner in which carbons are treated. A rapidly deposited carbon is very hard and more efficient than one deposited at a lower temperature, which is soft and mealy; but the hard deposit is in lumps, which appear under the microscope to be united only to the main carbon at their basis; a hard, almost flint-hard, carbon (for there is such) is longer lived than a soft one, but the latter is oftentimes the more efficient. I refer here to untreated ones.

The fact then appeared to me that the soft carbon (porcupine description) with a jacket forced upon it which it cannot throw off or ruffle, would be *the* carbon. So, having decided the first or base, the question then arose, With what sort of jacket should it be covered? I was not entirely satisfied with the treating or improving in hydrocarbon alone, and having exhausted, as far as I knew, the vegetable fibres, I tried animal of all kinds except the Chinaman's hair, which, I learn, some one has actually patented; and I found that, size for size, the animal carbons were behind the vegetable in efficiency, but they could be used much smaller, considering that they were not so disposed to disintegrate.

Experiments then showed that a carbon, which was exceedingly efficient but too soft, coated with a fine animal carbon, wonderfully lengthened its life and allowed of its being brought to a very high incandescence without destroying it. The vegetable may be softened by an alkali and wrapped with an animal filament, and, after carbonising, both are found to be united almost as one. In fact, the vegetable has a coat upon its back which fits so tightly that it is compelled to keep its own on. Again, in large carbons for ten amperes a large amount of heat is produced, and if that heat could in some way be used before it left the carbon it would be beneficial. It will be found that a large carbon built up of a number of small ones intermixed with glass in a very finely spun state, and then wrapped, as described above, with any good animal carbon (of course this is done before carbonising) will be very efficient, the carbon communicating sufficient heat to the finely divided particles of glass throughout its structure, and rendering them conductors for the time being. A carbon of this construction appears to remain hot for a considerable time after the current is cut off. Coating the vegetable fibre with another material, whether animal or vegetable, greatly increases the surface. If this carbon is heated to a high state of incandescence innumerable miniature semi-arcs appear to be formed all over its surface, wonderfully increasing its light-giving powers.

Another important point to be considered is the preparation of the material before carbonising. Many substances require little or none, but the greater portion must pass through a certain change first; some have a gelatinous or sappy substance contained therein, which if not removed or changed will cause miniature explosions within the material itself and the fibres will be ruptured. This must be most carefully avoided. A carbon which under the microscope appears to be a bundle of loose threads is of little value for incandescent lamps. You may treat or improve it if you like, and so cement the fibres together that to all appearances you have a good, hard carbon; but its backbone is weak, and an overcoat upon that, buttoned ever so tightly, provided it is made up of semi-detached particles (only cemented together at their bases and extremities, which is the case with a deposited carbon deposited in the usual

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way), will never make it long-lived. But it will be constantly increasing in resistance from the time it is put upon the circuit. If you have a fibre which, when baked, cakes or cements itself in a solid homogeneous mass, exhibiting no loose, hair-like projections, then you need not trouble about subjecting that material to any process before carbonising. On the other hand, as I have tried to show, a good material which cakes or cements itself to itself and to any substance upon which it is wound or braided, will sometimes save the weaker fibrous material upon which it is so wound.

In baking, also, it is of the utmost importance that that process be not carried too far, for you want the life of the carbon in the lamp not burnt out in the furnace. But at the same time you must bake enough. It is possible to bake so little that the filament when removed from the moulds, although to all appearance perfect, is virtually no conductor at all. Carry this a little farther and it becomes a poor conductor, but is not sufficiently changed to be of any use, for as soon as the current is forced through it, it bursts with a snap and a ring, like steel wire. After this stage the conductivity increases to a certain point, when it again decreases, this time on account of the carbon gradually wasting away, and you are in fact burning the very life out of it. The point is to catch it just when it is the best conductor and before the unnecessary wasting away process commences. This can only be ascertained by repeated tests and great attention to the regularity of the heat. The heat should also be applied to the mould, crucible, or whatever form of receptacle you use to contain your fibres, as evenly as possible. The whole should be brought to a glow throughout and at all parts at one time. I have carbons which were baked so that their extremities, that is, where they are connected to the platinum, were overbaked and ruined, while the bow or upper part was scarcely done. Examining this carefully through a microscope, the ends were found to be weak and frayed out and useless, while the upper part, or bow, was solid, glossy, and appeared to consist of an entirely different material.

Again, some substances may be baked in bundles bound together, each one keeping its neighbour in place, while others would cement together in such a manner as to render them useless. Do not bake too many in the same receptacle at one time, or so much gas will be given out that partial combustion will ensue unless you have some means of pumping out the occluded gas as fast as produced. Some substance, such as camphor, placed within the retort will sometimes enable you to bake successfully a material which otherwise would be useless. I have burning at the Russel House lamps which contain a vegetable carbon surrounded by an animal carbon. The vegetable alone in this case would be useless, but the animal covering preserves it and renders a high state of incandescence possible without disintegration. In fact it can, without injury, be maintained at so high a state of incandescence as to produce a bluish tint which enables you to readily distinguish colours. The efficiency of the carbon in this lamp is a little over one watt per candle-power. I am manufacturing these lamps for the Jenney Electric Company, of Indianopolis, and find them very efficient.

Mr. SLATTERY expressed briefly his dissidence from Mr. Hickley on some points, and avowed some incredulity with regard to the "one watt lamp," Mr. Hickley claiming a consumption of only 425 watts for 400 candle-power.

Mr. HICKLEY remarked that his materials and line of research were different from Mr. Slattery's ; hence, perhaps, the variant results arrived at.

COMPANIES' MEETINGS.

The United Telephone Company of the River Plate.

The fourth ordinary general meeting of the United Telephone Company of the River Plate (Limited) was held at the offices of the Company, 131, Wool Exchange, London, E.C., on Tuesday, the 12th October, Mr. F. W. Jones in the chair.

The SECRETARY (Mr. Geo. W. Rhodes) read the notice convening the meeting, after which

The CHAIRMAN, in alluding to the three and a half years' of the Company's working in the River Plate, said that the capital expenditure during that period, as well as the working expenses, had been paid out of the earnings, and that it was very gratifying to be able to state, as the result of this expenditure, that the paying subscribers had increased from about 300 to over 1,600, and their annual value from £6,400 to over £30,000. In addition, he would say that the contingent and other debt of the Company had been lessened during the same period by over £4,000. The increase of subscribers during the last nine months had more than doubled the increase of the preceding nine months, and the income of the current year would doubtless exceed that of the last by upwards of £5,000. Continued progress was never so well assured as at present, as the growth and development of the River Plate, which have been great factors in the progress of the Company, were now more than at any time in the past to be relied upon. Amalgamation in Buenos Ayres with the River Plate Telephone and Electric Light Company, had been under discussion for a long time, and a provisional agreement on the subject had been signed in Buenos Ayres last March. Several conferences upon this agreement had taken place, but up to the present time it was not possible to announce that there had been any definite settlement in regard to its provisions. The Directors had been prepared to recommend the acceptance of this agreement by the shareholders, but as a decision in regard to the details attending amalgamation had not been arrived at by the Directors of the River Plate Company, no recommendation could at present be made. Since the signing of the agreement the relative positions of the two companies in Buenos Ayres had materially changed. The revenue, which six months ago appeared to be about equal, was now about 12 per cent. in our favour, and everything indicated a rapid increase in this percentage. Delay in amalgamation, though for some reasons to be very much regretted, was not likely to result to the ultimate disadvantage of this Company. The rates had been raised from below to above those of the River Plate Company, without loss in the number of subscribers. The new subscribers in the last three months had exceeded those of any other like period in the history of the Company. The reports and accounts having been adopted, the Chairman moved a vote of thanks to the Resident Director in the River Plate (Mr. Adolph Fels) for the able manner in which he has conducted the affairs of the Company there. A vote of thanks was also passed to the *employés* in Buenos Ayres for their energy and devotion to the Company's business. The retiring Director and Auditor having been re-elected, the meeting terminated with a vote of thanks to the Chairman.

Direct Spanish Telegraph Company.

Notice is given that an extraordinary general meeting of this Company will be held at Winchester House, 50, Old Broad-street, E.C., on Tuesday next, at three o'clock, when the subjoined resolutions, which were passed at the extraordinary general meeting of the Company held on the 30th ult., will be submitted for confirmation as special resolutions, viz :—"That in consequence of the abandonment of the Company's original cable, the capital of the Company be reduced from £190,000 (at present represented by 6,000 preference shares of £10 each, all issued and fully paid up, and 13,000 ordinary shares of £10 each, whereof 12,931 are issued, and have £9 per share paid up, and 69 are unissued) to £95,000, and that such reduction be effected by writing off £5 per share from the amount credited as paid up on each issued share, and £5 per share from the nominal amount of each unissued share, the amount so written off the issued shares being capital not represented by available assets."—"That the Directors may make such regulations as they think fit for exchanging the certificates of shares for certificates in conformity with the foregoing resolution."

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. OCT. 13.		BUSINESS DONE WEEK ENDING OCT. 13. Highest.		Lowest.	
Anglo-American	34½,	35½	..... 34½	.....	—	
Do. Preferred	56,	57	..... 56½	.....	56½	
Do. Deferred	11⅞,	12¼	..... 12¼	.....	11¼	
Brazilian Submarine	10⅞,	11⅛	 11	.....	10⅞	
Cuba	11⅛,	11⅝	..... 11⅝	.....	—	
Do. Preference	18,	19	..... 18½	.....	—	
Direct Spanish	1½,	2	..... —	.....	—	
Do. Preference	8½,	9½	..... —	.....	—	
Direct United States Cable	8⅞,	9⅛	..... 9⅛	.....	9	
Eastern Telegraph	10⅞,	11	..... 11⅛	.....	10⅞	x.d.
Do. 6 per Cent. Preference	14½,	14⅝	..... —	.....	—	x.d.
Do. 5 per Cent. Debentures, 1899	105,	108	..... —	.....	—	
Eastern Extension	11,	11¼	..... 11½	.....	11⅛	x.d.
German Union	9⅛,	9⅜	..... —	.....	—	
Globe Telegraph and Trust	5½,	5⅝	..... 6⅜	.....	5⅜	
Do. Preference	12⅞,	13⅛	..... 13 7-16	.....	13 1-16	
Great Northern	13⅛,	13⅜	..... 13⅛	.....	—	
Indo-European	35,	36	..... —	.....	—	
Reuter's	6⅞,	7⅛	..... —	.....	—	
Submarine	195,	205	..... —	.....	—	x.d.
West India and Panama	⅝,	¾	..... —	.....	—	
Do. 1st Preference	8½,	8⅝	..... 8⅜	.....	8¼	
Western Brazilian	6½,	6⅝	..... 6 11-16	.....	6⅝	
Western Union 7 per Cent. 1st Mortgage	118,	122	..... —	.....	—	
Do. 6 per Cent. Sterling Bonds	101,	103	..... —	.....	—	

TELEPHONES.

Consolid. Telephone and Maintenance	13-16	15-16	.....	—	.....	—
Oriental	3-16	5-16	.....	—	.....	—
United Telephone	14½,	14⅝	.....	14 11-16	.....	14⅝

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	2½,	2⅞	.....	—	.....	—
Do. (fully paid)	4,	4½	.....	—	.....	—
Swan	¾,	1¼	.....	—	.....	—
Maxim Weston	3-16	5-16	.....	—	.....	—

MISCELLANEOUS.

Telegraph Construction	39	40	.....	39⅜	.....	39½
India Rubber, Gutta Percha, and Telegraph Works	24	2	.....	24 7-16	.....	—

TRAFFIC RECEIPTS FOR SEPTEMBER, 1886

COMPANIES.	Sept., 1886.	Sept., 1885.	Increase.	Decrease.
Cuba Submarine	2,250	2,160	90	—
Direct Spanish Telegraph	1,751	1,793	—	42
Eastern Extension	30,107	41,845	—	11,738
Eastern Telegraph	40,778	47,849	—	7,071
Great Northern	25,600	—	—	—
West Coast of America	3,585	—	—	—

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NOTES.

THE WEST INDIAN CABLES.—The cable between St. Vincent and Barbadoes is now repaired.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 15th inst. amounted to £4,044.

THE THOMSON-HOUSTON COMPANY.—This company reports an output of plant for 621 arcs and 2,600 incandescents during the month of September.

INDO-EUROPEAN TELEGRAPH COMPANY.—The Board have declared an interim dividend for the half-year ended June 30 last at the rate of 5 per cent. per annum, being the same as at this time last year.

THE WEST AFRICAN CABLES.—Telegraphic communication has now been established with Gaboon, Grand Bassam, Loanda (St. Paul de), Porto Novo (Kotoonou), and the Islands of Principe and San Thomas.

OBITUARY.—The death is announced of M. Dubosc, the Paris optician, whose name is associated with that of M. Leon Foucault in the construction of the earliest form of automatically regulated arc lamps.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended the 15th inst. are £1,816, as compared with £1,998 in the corresponding period of 1885.

MEXICO.—The Mexican telegraph system is undergoing a thorough re-organisation. More than 30,000 new posts and 400 kilometres of wire have been re-erected, and several important new lines are about to be undertaken.

SHEFFIELD.—The number of messages passed through the Sheffield Telephone Exchange last week was 32,096. This is the largest number since its establishment, being an increase of 13,556 on the corresponding week of last year.

NEW ENGINEERING TREATISE.—We are informed that Messrs. Whittaker and Co. will issue in the course of next week a book "On the Conversion of Heat into Work," a practical handbook on heat engines, by Wm. Anderson, M.I.C.E.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended October 15th were £3,215, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

ACCIDENT IN FRANCE.—According to the Paris correspondent of the *Daily Telegraph*, a "peculiar and serious accident" happened on Wednesday last at the Grand Hotel, Paris. The "generating tube of the electric light machine burst," and two men were severely scalded.

AN UNFOUNDED REPORT.—One of the daily journals recently contained a report that a fatal accident had occurred at the works of Mr. H. J. Dale, the electrical instrument maker. We are glad to be able to state that the report is entirely without foundation.

ANGLO-AMERICAN TELEGRAPH COMPANY.—At the last meeting of the Board of Directors of this Company it was resolved that the balance of the revenue account for the quarter ended September 30th last, amounting to £16,500, be placed to the credit of the renewal fund.

SPANISH TENDERS.—The Madrid *Gazette* announces that on November 2nd tenders will be received at the office of the Director-General of Posts and Telegraphs, for the supply of 5,700 posts for the State telegraphs, viz., 3,500 of a length of 6 metres, 1,000 of 7 metres, and 1,200 of 8 metres.

DIRECT UNITED STATES CABLE COMPANY.—The Board of Directors of this Company have resolved upon the payment of an interim dividend of 2s. per share, being at the rate of 2 per cent. per annum for the quarter ended 30th September last, the dividend to be payable on and after the 30th inst.

THE RECENT STORM.—The terrific storm which visited the south and south-west coasts on Friday last caused considerable devastation to the telegraph lines. For about twenty-four hours many parts of these districts could not be reached by telegraph, and one of the Atlantic cables belonging to the American Cable Company was disabled.

THE LIGHTING OF THE HOTEL DES POSTES.—We recently stated that it had been decided not to adopt the electric light for the new Post Office in Paris. This decision has been carried into effect, and the work of laying the gas pipes is just completed. At this stage it has just been determined to reconsider the question, and it appears probable that, after all, an electric installation will be provided.

THUNDERSTORMS.—Severe thunderstorms occurred on Tuesday night last in the districts of Windsor, Aldershot, Guildford, and Oxford. At Aldershot Camp several telegraph posts were split up and the lines destroyed. Rosehill House, an isolated residence in the neighbourhood of Maidenhead, was set on fire by the lightning and burnt to the ground. On the following day Essex, Cambridge, Hertfordshire, and Derby were visited by the storm.

ELECTRIC SIGNALLING IN THE NAVY.—The Admiralty have issued instructions for a flotilla of gunboats, consisting of the "Avon," "Cherub," "Firm," "Forester," "Argus," and "Amelia," to be despatched on a short cruise in the Channel for a series of experiments with electric semaphores for night signalling. The tests will be made under the superintendence of Admiral Sir William Dowell, K.C.B., and the members of the Signalling Committee.

ELECTRIC LIGHT STATISTICS FOR FRANCE.—According to a statement recently published the following figures are supposed to represent the present state of electric lighting inFrance :—1,044 installations, 5,870 arcs, 55,321 incandescents. We do not quite understand how precise and reliable statistics (note the odd lamp) of this character are obtained, if we did we should be glad to avail ourselves of the process to obtain the figures for this country.

BURNLEY.—The public illuminations at Burnley, to which we recently referred, were maintained from a 5A Gülcher low tension dynamo, driven by a Marshall 14 horse-power compound portable engine. Thirty-five horse-power (actual) are absorbed at the dynamo, for which a total light was obtained equal to 55,000 to 60,000 candles. Although heavy rain was falling almost incessantly nearly every day, the whole of the work was completed in five days.

THE MACHINERY AND HARDWARE EXPORT CATALOGUE.—The second annual edition of this useful publication has just been issued by "The Machinery and Hardware Company," of 147, Queen Victoria-street. The work is carefully indexed and has been compiled from the latest obtainable information and price lists. We have pleasure in recommending the publication to the attention of electrical firms wishing to extend their connections with Foreign and Colonial buyers.

MAGNETITE FOR DETERMINING LINES OF FORCE.—The mineral known as magnetite, which consists chiefly of the magnetic oxide of iron, when finely powdered may be used with great advantage for determining the direction of the lines of force in a magnetic field. It readily admits of being reduced to the condition of a very fine powder, and its specific gravity

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being much less than that of iron, good figures can be obtained from fields too weak to give satisfactory results with iron plugs.

THE PARIS INTERNATIONAL LABORATORY.—The Municipality of Paris has granted a portion of the site of the old Collège Rollin to the International Society of Electricians for the purpose of the electrical laboratory which is to be built and equipped out of the surplus funds of the Electrical Exhibition of 1881. The laboratory will be open for purpose of research to electricians of every nation, under regulations which will be drawn up by the International Society of Electricians.

INSTALLATION AT MESSRS. PETER ROBINSON'S.—Mr. E. Carver is putting down an extensive installation of electric light at Messrs. Peter Robinson's, the well-known drapers in Oxford-street. The installation when completed will comprise three Phœnix dynamos to supply 40 Pilsen arc lamps and one Edison-Hopkinson, which, in conjunction with 53 E.P.S. cells, will supply 300 20 candle-power incandescent lamps. We may shortly avail ourselves of an opportunity to describe this installation at greater length.

NEW SECONDARY BATTERY.—A new accumulator cell has been brought out by M. P. Gadot. The principal feature of novelty appears to be in the shape of the holes in which the active material is placed. The plates are cast in two halves, and the holes have the shape of truncated cones or pyramids. The two halves are then placed one on top of the other with the widest sides of the holes in juxtaposition. In this way cells are formed, having a large interval capacity with comparatively small openings upon either side.

ROYAL ENGINEERS AND THE POST OFFICE.—The Postmaster-General notifies that arrangements have been made at the instance of the Secretary of State for War that non-commissioned officers and men of the Royal Engineers, on being pensioned or discharged, or transferred to the reserve, may, at the discretion of the Postmaster-General, be appointed to certain situations in the Post Office. This notice will probably operate chiefly in respect to telegraphists, of whom there are a considerable number in the corps of the Royal Engineers.

BOOKS AND CATALOGUES RECEIVED.—We have received from the Commissioners of the Colony of Victoria a copy of their handbook, giving a detailed account of the resources of that colony.—From Messrs. Marshall and Co. we have received a copy of the specification of their "improved high-pressure self-contained fixed steam engine."—Mr. Bunstead sends us his illustrated catalogue of high-speed "silent" engines.—Messrs. Willem Smit and Co., of Slikkerveer, Holland, send us their illustrated catalogue of dynamos and arc lamps.

EARTHQUAKES.—An earthquake shock occurred in Central Europe on Monday last, and was distinctly felt as far west as Strasburg. According to a Reuter's telegram a severe and prolonged earthquake occurred in Cashmere on the night of October 19th. It was succeeded by a fall of "numerous and brilliant meteors, which continued until morning." This is clearly a case in which the *post hoc, propter hoc* argument should not rashly be applied; but it is not surprising to learn that the native mind thinks otherwise, and great alarm prevails.

ANOTHER TELPHERAGE SYSTEM.—Mr. Van De Poele, whose name is well known in America in connection with electromotors and railways, has recently elaborated the details of a telpherage system. From the published accounts it would appear, however, that this system would be more correctly described as an overhead electrical railway. Mr. De Poele provides substantial iron standards, which are erected side by side in pairs, and carry two parallel insulated hangers upon which stout copper cables are supported. Upon these the wheels of the motor will run, the cars hanging below in the usual manner.

THE EDISON COMPANY.—The Edison Company of New York has just published its latest list of work done. The circular shows a total of 181,463 lights in isolated plants and 149,900 in central stations, making in all 331,363 lamps actually placed. The returns cover ten months, from Oct. 1, 1885, to Aug. 1, 1886, and exhibit the following percentages of increases:—Isolated plants, 35 per cent.; lamps in same, 36 per cent.; central station plants, 132 per cent.; lamps in same, 126 per cent.; isolated plants, increase 182; isolated lamps, increase 48,588; central station plant, increase 33; central station lamps, increase 83,600.

ANOTHER CITY INSTALLATION.—Messrs. Wheatley Kirk, Price, and Goulty, the well-known auctioneers, have recently fitted their offices in Queen Victoria-street with electric light. Steam power being already in use upon the premises for working the passengers' lift and for other purposes, it was found possible to make use of the boiler already fixed. A small vertical engine drives a Crompton dynamo, giving 25 amperes and 90 volts. The machine is employed to charge 36 cells of the "Consolidated" type, and these light nineteen 20 candle-power 72-volt lamps. The installation has now been running for several weeks, and has given great satisfaction. We understand that the installation was fitted up by Mr. F. W. Suter.

AN IMPORTANT DISCOVERY.—We understand that a discovery of some importance has been made at the Munich Public Electrical Laboratory. A new alloy of nickel, to be called "nickeline," has been found to possess a specific resistance considerably higher than that of German silver, together with a still smaller temperature coefficient. Some little doubt rests at present upon the accuracy of this statement, as the figures given by the authority from which we quote are not of an intelligible character. If the information is correct the Munich Public Laboratory, of whose constitution an account will be found in our issue of the 27th August last, will have fully justified its existence.

ELECTRICITY AS A DETECTIVE.—Electric fire and burglar alarms, although not yet so extensively adopted as they well might be, are, nevertheless, articles frequently inquired for in the trade. Messrs. Northam and Co., of Sheffield, inform us, however, that they recently had an inquiry for burglar alarms, which were to be fitted in a low-class lodging-house in Sheffield, for the purpose not of keeping burglars out, but to prevent the thieves within from dropping sheets and blankets out of the windows to confederates beneath. We have no doubt that the proprietor will find that electricity will do him good service in this respect, and we shall not be surprised if some enterprising firm takes up this idea and issues a circular to the lodging-houses of Seven Dials and Ratcliff-highway.

TELEPHONY.—The Northern District Telephone Company is still extending its already extensive system of trunk wires. Last week a new line connecting the Durham Exchange with those at Sunderland and the Tyneside was completed with great success by this enterprising company, which intends shortly to continue its wires to Blyth and Bishop Auckland Durham is now brought into communication with Middlesborough, Stockton, Darlington, East and West Hartlepool, Sunderland, and the Tyneside towns, and when Blyth is connected also a new field for telephone enterprise will be opened to the company, as both Durham and Blyth are thickly surrounded by collieries, and these require ready communication

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with their head offices, which the company will be able to give them.

POST OFFICE TELEGRAPHS.—The Post Office has issued a new edition of their book of diagrams of telegraph and telephone circuits. The number of plates has been considerably increased, and the shape of the book has been altered to small 8vo., rendering it more handy for reference than in its previous oblong form. The diagrams are excellently engraved, and even in the most complicated circuits the connections may be traced with great facility. The explanations are printed as a rule upon the pages opposite to the diagrams to which they refer, and plenty of space is left for private notes. The Post Office system is frequently made the object of depreciatory remark in the daily press, but beyond all doubt it is the finest and most efficient system of telegraphs that exists in any part of the world.

GREAT GRIMSBY.—The first installation of the electric light in this town has just been made at the factory of the Great Northern Ice Company by Messrs. Swete and Main, under the personal supervision of the company's chief engineer, Mr. E. H. Tompkins. The installation is on the incandescent principle, and consists of 25 Swan lamps of 16 candle-power, each being fitted with a cut-out and switch. The dynamo is one made by the late firm of Oppermann Brothers, and is driven direct from a 6 horse-power horizontal steam engine, which is also used for driving a set of ammonia pumps, against a pressure of 180lb. on the square inch, the engine running at 100 revolutions per minute. The installation is a great success, and is interesting as being, we believe, the first utilisation of the electric light in an artificial ice factory.

THE BRIGHTON ELECTRIC RAILWAY.—The severe storm which raged upon our sonthern and western coasts on Friday and Saturday last did considerable injury to the electric railway upon the beach at Brighton. We are, however, very glad to be enabled to state that the reports which appeared in some of the daily papers, to the effect that the railway had been almost entirely swept away, were very much exaggerated. The most serious damage is confined to a length of about 150 yards, and here the destruction is, indeed, practically complete. The shingle was washed from under the sleepers, and the rails were then torn and twisted in a most remarkable manner. We are sure that our readers will sympathise with Mr. Volk's misfortune, but it is fully anticipated that the little line will be again in working order within a few days.

A CHALLENGE.—The *New York World* says :—"There has always been sharp rivalry between the several electric light companies, but the war waged between the American, of this city, and the Thomson-Houston, of Boston, has been conducted with unusual ferocity. It has now reached a point at which the New Yorker boldly challenges the Bostonian to a test of the respective merits of the two systems. As the forfeits are to go to the Charleston sufferers we are disposed to urge the Thomson-Houston and all other companies to promptly 'put up or shut up.' The American company, which issues the challenge, is the one which General Stone and the Lighthouse Board have selected to light the torch of Liberty. Mr. Goff, the president of the company, on being informed that his proposition to supply the apparatus had been accepted, made a gift of it to the Government."

AN AMERICAN OPINION.—The New York *Electrical Review* has the following paragraph, which enables us to see "how it strikes a contemporary :"—"A gentleman well known in scientific circles lately returned from Europe, in speaking of the relative progress of electric lighting in England and the United States, expresses the opinion that while not much has been done on a large scale in the way of installations for general distribution of electric current in the cities and towns of England, still the growth is an extremely healthy one. The number of installations in private residences is extremely large. Especially successful are numerous storage battery plants, the motive power for the dynamo being usually a gas engine. It is a matter of regret that more attention has not been given in this country to domestic incandescent installations."

THE LIGHTING OF BROOKLYN.—According to the Brooklyn *Union*, that city is lighted by 825 electric lamps and 11,137 gas lamps. The former cost $182.50 each per annum, and the average cost of the gas lamps is $21.50. When electricity was introduced it was on the basis of one electric light taking the place of 7½ gas lamps. In reality each electric light replaces about 4⅓ gas lamps. Had the substitution of electric lamps for gas been effected on a basis of 1 to 7½, the former would even then have cost $17,520 more than the gas lamps ; but as it is, the city pays $76,280 more for the electric lights than the displaced gas lamps would cost. Brooklyn's appropriation for street lighting this year is $360,000, whereas the city has incurred obligations amounting to $390,000. If all the gas lamps were replaced by electric lights the city would have to pay $633,600 for its street illuminations.

A TOUR OF INSPECTION.—During the past summer Prof. Plympton, who is one of the members of the Brooklyn Underground Wire Commission, visited Europe for the purpose of studying the underground wire systems of this country and the Continent. In his report to the commissioners the professor intimates that he has practically had his journey for nothing. The only underground systems which he succeeded in discovering were those of Paris, Bordeaux, Antwerp, Berlin, and Newcastle-upon-Tyne. The London Post Office service, which comprises an underground system of very respectable dimensions, should certainly have attracted his attention ; but from its omission we suppose that the professor's inquiries extended only, or chiefly, to electric light and telephone wires. The report speaks in somewhat contemptuous terms of the position of the European countries in the matter, and contains the following passage :—"To the subtle and critical questions raised by these conditions [that is, the conditions of underground electric communication in general], foreign experts are absolutely dumb. They may be thinking unutterable things, or they may be making in secret indescribable experiments ; but they have reached no results, and they regard Americans engaged in that line sometimes with awe as superior beings, sometimes with amazement as persons who rush in where superior beings fear to tread." With all due courtesy to the learned professor, we must ask his permission flatly to disclaim the idea that English electricians look upon their American *confrères* either upon the one hand as fools or upon the other as preternaturally gifted beings. Without entering into any barren controversy, we may briefly call attention to the fact that the necessity for burying the wires has become urgent in America at an earlier date than it has in this country, not merely from the more general use of the telephone, but also from the fact that the use of street pole lines was at first tolerated in the States, whereas all our overhead lines in cities are also over house. As matters stand, we can well afford to wait a while in order by-and-bye to profit by the invaluable experiments which are now being undertaken in the United States.

A VOLTAMETER VOLTMETER.—A voltmeter based upon the electrolysis of water has recently been devised. It is scarcely a commercial article, but as the instrument is inexpensive and

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easily made, it may sometimes find a place in the laboratory of the electrical amateur. The following description of the construction and use of the instrument will probably be intelligible, but we shall leave to the aforesaid amateur the interesting and instructive task of determining for himself the method of calibrating the instrument. Two glass tubes, each, say, 16 millimetres diameter and 50 centimetres in length, are held by brass clamps which are attached to a wooden rod. Tube A is closed at the upper end by a stopcock, or a short piece of vulcanite tubing which can be squeezed tight by a screw-clamp will serve equally well. The lower end is closed by a well-fitting cork, which projects, say, an inch beyond the tube. Through this cork passes a pair of platinised (or carbon) electrodes. The cork has also a wide hole bored first half way through from the upper side, and then outwards horizontally, so as to form a lateral communication with the tube itself. A short piece of glass tubing is fixed in the lateral opening, and over this passes one end of an india rubber tube, say 2ft. in length, the other end of which is slipped over the lower end of tube B. This last tube is open at both ends. The stopcock on A being open, acidified water is poured into B until its level stands about midway in each tube. Tube A being provided with a scale graduated in centimetres, the apparatus is complete. The method of use is as follows: The stopcock remaining open, tube B is raised by sliding the clamp up the rod until the level of the water reaches nearly to the top of the scale on A. The stopcock is now closed, and the electrodes are connected to the points whose difference of potential is required. After the current has been passing for a few minutes—the time being carefully noted—the height of B is again adjusted until the liquids are at the same level in the two tubes. We can then find from the scale reading the number of cubic centimetres of liberated gas at atmospheric pressure. If care is taken always to use diluted acid of the same strength, the resistance between the electrodes can be determined once for all.

Spanish Telegraph Statistics.—In April last we gave some particulars of the working of the Spanish telegraph service during the first six months of 1885. The official statistics for the second half of the year have now been published, and show a satisfactory, though moderate, improvement. The number of new stations opened to the public during the six months was 30, of which 29 belonged to the railway companies and one to the State, as compared with an aggregate of 15 in the first six months. Only one station was closed. The increase of wire was 167 kilometres as compared with 108 in the first half of the year. The number of stations belonging to the State was 533, those of the railway companies open to the public 359, municipal 15, private 1, and semaphoric 6. As regards the number of despatches, the return shows a total of 1,332,394 messages in the interior, of which 1,075,866 were private telegrams, as compared with 1,245,326 and 982,291 respectively in the first six months. The foreign telegrams numbered 342,202, as against 362,765. The item included in the Budget for the telegraph service was £120,437, and the revenue accruing to the State for the six months under review was £138,893. There was therefore a profit. The revenue for the first six months was £101,000 only. It is interesting to note that of the 902 interruptions, of more than six hours' duration each, 630 were owing to bad weather, 120 were from decay, 119 were from causes unknown, and 32 were intentional breakages. Since writing the above we have received the Madrid papers of Saturday last, and observe that some dissatisfaction exists among Bourse speculators with respect to the delivery of foreign telegrams. Bitter complaints are heard in some quarters about the efficiency of the service. It will be observed in the statistics given above that although the number of messages circulating in the interior showed a satisfactory increase, the foreign telegrams for the half year showed a falling off, and it is urged that this falling off is likely to become much more marked unless the authorities take measures to improve the service. It is alleged that messages despatched from Paris or London at three o'clock in the afternoon are not delivered in Madrid until eight or nine o'clock in the evening, if not later. Errors in transmissions are also complained of.

A New Method of Making Incandescent Filaments.—The Wollaston process of obtaining fine platinum wire consists, as is well known, in enclosing the wire, before the drawing process, within a thicker wire or tube, and after the drawing process, dissolving the silver off by nitric acid. We understand that Mr. Robert Dick, of Glasgow, has invented a somewhat analogous process in order to obtain fine and dense carbon filaments for his incandescent lamps. Mr. Dick has tried a variety of materials, such as silk, cotton, paper, &c., but finds the fibres of the kitool plant specially adapted to his purpose. (What kind of a vegetable is the kitool?) In using these fibres he draws them through fine steel draw plates or dies with sharp cutting edges to a uniform size. The fibres so prepared are then enclosed in a fine copper tube, the fibre being much longer than the copper at this stage, to allow of the tube being drawn over the fibre. These tubes are then drawn down, which reduces their diameter and compresses the material within them to the desired density. The compressed tubes, with the filaments thus formed in them, are then cut into suitable lengths and bent or shaped approximately to the desired form the carbons are intended to retain in the lamps, which admits of their being rolled into spirals or other shapes, in which state they are carbonised within the tubes under pressure by heating them to bright redness in a plumbago crucible in the ordinary way. After this carbonisation of the filaments, the copper tube or other metallic coating is removed from the greater part of their length, or wholly removed by immersion in nitric acid, or by electrolysis. Part of the metallic coating may, however, be left at the ends to serve as convenient means of connecting the filaments to the conducting wires of the lamp. The employment of the metallic tube serves the purposes of compressing the material forming the filament placed within it, and of maintaining the pressure and shape during the carbonising process. The advantages, according to Mr. Dick, obtained by this compression of the carbon-forming material during its formation and carbonisation are many: First, it strengthens the filament mechanically; second, it enables the carbon to give a high specific amount of luminosity per unit of energy expended on it in the lamp, thus rendering the carbon filament a very durable and economical medium in incandescent lamps for electric lighting.

The Cowles Electrical Furnace.—Prof. Mabey has recently stated that in experimenting with the Cowles electrical furnace it has been found that its efficiency could be largely increased, and the rather rapid formation of graphite prevented, to a certain extent, if the charcoal were coated with lime previous to using it. It was also found that the quantity of product formed was increased when the electrodes were allowed to enter the mixture of ore and carbon in an inclined position, at an angle of about 30° from the horizontal plane. A continuous reduction is more easily effected when the electrodes are capable of being drawn apart so as to gradually expose fresh portions of ore to the action of the current. The Professor continued:—"In the discussion that followed a paper read by Dr. Mehmer, of Berlin, Dr. Martius was inclined to the belief that the metallic aluminum was of no greater value

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for ornamental purposes than zinc, and that its alloys possessed no properties relating to corrosion, strength, &c., that were worthy of mention. These assertions can best be answered by referring to the actual properties of these metals which are established beyond doubt. But the opinion expressed by Dr. Werner Siemens that, so far as practical results are concerned, this electrical furnace is identical with that constructed by his brother, Sir William Siemens, is of more importance. The continuous working of an electrical furnace requires as nearly as possible a constant resistance between the electrodes Assuming that a dynamo machine was carrying the energy from 300 horse-power and distributing it in an arc a few inches in length, and that suddenly the arc was broken by the introduction of fresh material, the effect upon the dynamo can be imagined. Dr. Siemens thought that the reduction of aluminum depended upon the presence of copper, and he expressed doubts as to whether reduction would result in its absence. Reference was made to the statement that aluminum bronze had been made in a crucible furnace by fusing together copper, carbon, and corundum. We have tried the latter experiment at the highest temperature we could produce in a crucible furnace without the slighest reduction of aluminum. Nevertheless, it may be true that traces of aluminum can be introduced into copper by this method. The assertion of Dr. Siemens that aluminum could not be reduced without copper is erroneous. We have repeatedly taken mixtures of metallic aluminum and carbon from the furnace in large quantities. The question by another chemist as to whether any analysis of the products had been made followed a remark by Dr. Martius that they did not need to be informed by Americans concerning aluminum or its alloys."

A New Peroxide Battery.—Mr. I. L. Roberts contributes a paper to the New York *Electrical World*, in the course of which he propounds certain views as to the relation between chemical action and electricity, which although scarcely new are perhaps worth recalling. He says :—" It is probable that when coal is consumed in oxygen or a metal is burned in chlorine or fluorine, the action is electric; or, in other words, all chemical action first produces a current of electricity. But as we do not know how to attach binding posts to such elements, the current is not made manifest to our senses. As the currents thus made are entirely short-circuited on themselves, they produce only the phenomena of heat, as does the current in an ordinary battery when short-circuited on itself. As soon as we are able to get some way of conducting away the current from simple chemical union, then we will reach the ideal method of producing electricity. The ideal battery is one which will not deteriorate on open circuit, and will be constant on closed circuit. Both these qualities have been attained, but not in the same cell. Chromic acid as a depolariser is constant enough, while sal-ammoniac, as a single fluid, will not destroy on open circuit to an injurious extent. I think I may venture to say that the nearest approach to the ideal battery that has come before the public is one recently invented by myself and known as my Roberts peroxide battery. The main feature in this battery is the peroxide of lead which is used as a depolariser. It has been known in electro-chemistry for some time that peroxide of lead is one of the most powerful depolarisers, as used, for instance, in the secondary battery. But no commercial use has been made of it in primary batteries; because, first, it was a powder and difficult to apply to the purpose; and, secondly, it was too costly to put into competition with peroxide of manganese, which, though not so good, was cheap. It was the writer's fortune to discover how to make it cheap enough and solid enough to far outstrip manganese dioxide as a depolariser. It is made by adding to red lead permanganate of potash in a powdered form and well mixing them. To this there is added any acid which will decompose the permanganate, such as sulphuric, or preferably hydrochloric acid. This will unite with the alkali and liberate the permanganic acid, which is the most powerful oxidiser known to chemists. This will immediately unite with the red oxide of lead, Pb_2O_3, and produce PbO_2. The whole mass, if properly made, is in a semi-liquid form, and if poured into a mould containing a carbon, it will set in a few seconds. The mould can be opened, and the whole removed and dried, when it will be porous like a carbon and will be a conductor of electricity."

Electric Lighting in the Black Forest.—The (New York) *Electrical World* has the following:—To find the luxuries of a London drawing room on the side of some rugged mountain which our forefathers could have viewed with nothing but aversion, writes a correspondent, no longer causes surprise to any one. But there is a certain sense of anomaly in meeting in some remote region with a form of lighting which has been actually rejected in the city of London as too expensive an indulgence. To climb up thousands of feet by means of a railway which has obviously the hardest work to get along, and to penetrate into the heart of a vast assemblage of granite hills such as the Black Forest, and then to find a village street lined with these lofty posts which have scarcely yet become familiar to the capitals of Europe, and to drive in a flood of artificial moonlight, strikes one at the first moment as a little strange. Obviously, however, electric lighting is specially adapted for mountain districts. Rushing streams and tumbling cataracts supply working power in the most economic form, and reduce the expense of the new light to little more than the cost of the original apparatus. It seems to be an accepted view now that when gas or fuel is used to set in motion the dynamo machines which produce the electric current, about the same amount of combustible material is consumed as would give a corresponding, or at least a sufficient, light by means of gas. The preliminary expense of the electric work is so much to be added, and the total cost is thus raised far above that of gas; but when it is merely a question of diverting a fraction of a torrent, or levying a trifling contribution on a waterfall, the motive power is obtained for nothing, and the only permanent expense consists in the renewal of carbon pencils or other lamp apparatus, the wear and tear of machinery, and the expense of superintendence. At Triberg, near the summit of the Black Forest Railway—a place which boasts the best waterfall in South Germany—water is, of course, plentiful, and advantage has been taken of the fact. The principal streets of the village, which must be nearly half a mile long, are well lighted by nine arc lights, or Siemens lamps. The expense of the installation is said to have been 40,000 marks, or £2,000, and the standing expenses are inappreciable. One or two private establishments have also set up electric lights of their own. A bier-halle and a watch manufactory are lighted by incandescent light, and the Lion Hotel has a Siemens lamp in the speise-saal. The installation of this lamp cost 800 marks, or £40, and the only continuing expense consists in a few pfennig per night for renewal of carbons and a small rent for house room paid to a neighbouring manufactory in which the necessary water wheel and dynamo are placed. Another Triberg hotel, not to be outdone, promises shortly the incandescent light throughout its suite of public rooms; and this form of light is already introduced at Tarasp, on the Lower Engadine, and at the new hotel at the head of the Malojah Pass

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THE IMMISCH ELECTRO-MOTOR.

It will be within the recollection of many of our readers that at the International Inventions Exhibition of 1885 the firm of Immisch and Co. were awarded a silver medal in the class of electro-motors. Since that date, however, so little has been heard of the Immisch motor that it might almost have been supposed that a promising career had, unhappily, been blighted in the bud by some untoward misfortune. As a matter of fact this is, however, by no means the case. Messrs. Immisch have been occupied during the past twelve months in the experimental development of some very novel features in motor construction, and have been enabled to pursue the evolution of this particular type of machine through several important stages. Warned by the disastrous experience of others in a bygone era in the matter of dynamo-electric machinery, they wisely determined to withdraw to a large extent from the open market until the time had arrived when it should appear that, so far as they were themselves concerned, the experimental epoch was fairly over. As no details of the construction of either the earlier or the later types of this motor have as yet been made public, save in the form of Patent Office enigmas, our readers will no doubt be interested if we avail ourselves of the opportunity which a recent visit to the works of Messrs. Immisch has afforded us to lay before them a detailed account of the design and construction of these machines.

Before, however, we enter upon this task we must devote a few lines to the new premises to which the firm has quite recently migrated. The factory, in Maldon-crescent, Kentish Town, forms part of a very large and substantial building, and is thoroughly well adapted for electrical engineering work. It consists of four floors, each 95ft. by 38ft., and in addition there is a large flat upon the roof, which is used for the storage of accumulators. The machinery is driven by a 30 horse-power (nominal) Marshall engine, semi-fixed type, with boiler underneath. The engine is fitted with a Hartnell governor, and runs at 80 revolutions, driving on to a main counter shaft running at 150 revolutions, from which power is distributed by shafting throughout the first and second floors. The third and fourth floors, which comprise the brass-finishing, the winding lathes, and other comparatively light machinery, receive power from a six horse-power motor, which is supplied with current from a dynamo upon the ground floor. This arrangement is giving the most perfect satisfaction, and we understand that Messrs. Immisch intend shortly to put in a large dynamo, which will enable them to drive the machinery in the remaining shops by electro-motors, thus doing away with a considerable amount of shafting and belting.

We are also informed that a large motor is about to be supplied for driving the whole of the machinery in an adjoining factory, for which current will be furnished from the above-mentioned dynamo. Our space will not permit us to give a detailed account of the whole of the plant which has been laid down; but some idea of the substantial and permanent character of the operations contemplated will be gathered if we mention some of the more important machines which attracted our attention. On the ground floor is a planing machine weighing sixteen tons, and capable of working over a space 12ft. in length, 5ft. 6in. in width, and 4ft. 6in. in height. At the time of our visit this machine was planing out the armature space in the field-magnets of two dynamos intended for charging accumulators in parallel. These dynamos, we may mention in passing, will be 20-unit machines, with double commutators upon either side of the field-magnets. They are each intended to supply four circuits with 20 volts and 250 amperes; or, of course, these circuits may be coupled up in any other way as required. The advantage of this arrangement, enabling accumulators to be charged in parallel, is obvious.

The engineers' shop on the first floor contains some very fine machinery of modern construction. Among others we noticed a massive lathe made principally for turning fields after the planing machine has done its part of the work, and also a large double-table shaping machine, with 16½in. stroke embodying several recent improvements. This shop contains slotting, drilling, milling, and planing machines, together with a dozen lathes of various kinds. The brass finishers' shop contains seventeen machines of smaller size, which are driven by a 6 h.-p. series-wound electro-motor, as already mentioned We were informed that it is intended shortly to duplicate this plant (for which plenty of space is available), and that it was anticipated that the same motor would still be able to do the whole work with ease. This motor is illustrated in the accompanying figure. The dimensions of its bed are 2ft. 3in. by 1ft. 4½in., and the machine stands only 11in. high; it weighs about 350lb., and takes a current of 51·5 amperes at 100 volts when doing full work, showing an efficiency of conversion of 85 per cent.

The floor above is perhaps the most interesting to an electrician; here the armature cores are built up and the coils are wound. This latter process is carried out in a lathe, notwithstanding that the armatures are of the drum type. The connections, though of a somewhat complex character, are much simplified in practice by means of a particularly ingenious system of arranging the brass tags with which the ends of the various coils are labelled. The intricate character of this work will be better appreciated after a glance at the diagrams which we are about to describe, especially when it is understood that while these figures relate to an armature of only 6 coils at the most, yet in practice armatures of 48 and 96 coils are frequently wound, and one with as many as 144 coils is now in hand.

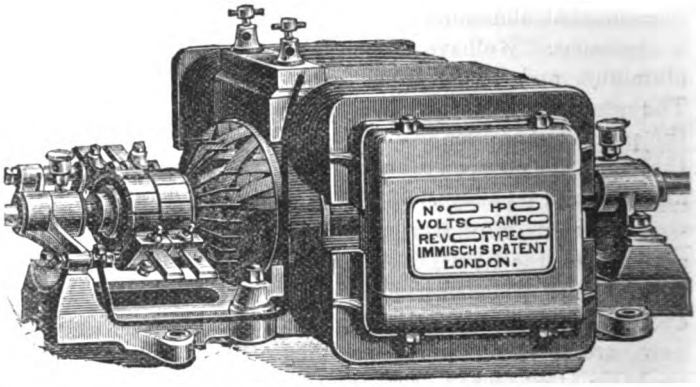

FIG. 1.—The Immisch Motor.

The main feature which is claimed for the Immisch motor, and which, so far as our inspection goes, would seem to be fully confirmed, is that of an entire absence of lead. From this follows a very nearly complete immunity from sparking, and the capability of reversible running by a mere reversal of the connections of either armature or field. It is further claimed that by means of the devices which we shall presently explain the uniformity and symmetry of the magnetic field are secured without resort to any wasteful method of compensation. These qualities undoubtedly render the motor particularly well suited for use with variable loads, as for instance with tramcar work, where not only is the load subject to continuous variation, but the direction of rotation has frequently to be reversed. Under these conditions it is not uncommon for motors, otherwise excellent, to give much trouble at the brushes.

The earliest motors constructed by this firm—now some four or five years ago—embodied an idea which did not, however, aim at securing a symmetrical field, but, on the contrary, sacrificed something in this direction in order to obtain increased efficiency by the avoidance of "dead points." In the present machines this latter advantage is still retained, in addition to the features already referred to; it will therefore be the most simple, and probably the most interesting method if we approach the present construction by means of a brief historical sketch tracing the evolution of the several ideas which are embodied in the latest type.

It is evident that if a motor have n poles in the field, and either $n+1$ or $n-1$ coils upon the armature, and if the coils be successively cut out of circuit at the time when the magnetic field due to this particular coil coincides in direction with that of the final resultant field then there can be no absolute dead point. This first idea was embodied in a somewhat crude

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form in a motor whose construction is seen at a glance in Fig. 2. But apart from other faults it is palpably evident that the strains upon the armature shaft are in this case very unevenly balanced, and in fact there resulted so severe a bending strain upon the shaft as to render the construction quite impracticable. The next step was to alter the form of the armature to that of a drum with Pacinotti teeth, to retain the three armature coils, but to wind them in two subdivisions placed at right angles to one another, and to reduce the pole pieces on the field to two only. The strains upon the armature shaft are now equal and opposite at all points, and a machine of this construction ran perfectly smoothly. With the object of avoiding a backward pull upon the Pacinotti teeth it was, however, found necessary to cut away the pole

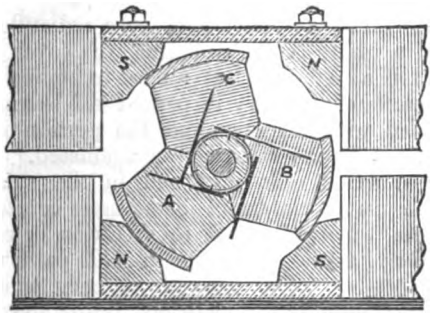

FIG. 2.

piece of the field upon the side from which the coils were retreating, as indicated in Fig. 4 (to which we shall have presently to make further reference). A three horse-power motor constructed after this manner was shown at the Inventions Exhibition last year, and gave an average efficiency of 75 per cent. Obviously, however, this construction involves the serious defect of requiring a rotation in one direction only. The magnets are also very costly to make in wrought iron. Malleable castings were tried for some time with good effect, but further improvements have enabled this construction of the field to be discarded.

Before, however, we describe the next advance, it is necessary to say something more about the principle involved in cutting out the coil, which is passing through the position at right angles to the position of the field. This device in one of several forms is common to all the motors which have been constructed by the firm. Its extreme value in preserving the symmetry of the field will be readily appreciated when we consider that the magnetic axis of the *armature* field itself always passes through this particular coil, so that its magnetic moment with regard to the actual resultant field is very small, while at right angles to this position it is a maximum, and hence its disturbing effect upon the resultant field would be also a maximum if it were left in circuit. The coil which occupies this position is deprived of its injurious influence either by open circuiting or short-circuiting. Each method has its particular advantages, but the latter is now most frequently adopted, because it lends itself to ring or cylinder as well as to drum-wound armatures. No injurious heating effect results from the short-circuiting so long as the field poles are properly proportioned. The same identical construction has been successfully applied to a dynamo, and a machine so made is now running at the Liverpool Exhibition. If the circuit be broken under full load no trace of sparking is observable. It is, however, necessary that the brushes be very accurately set when the construction is adopted for a dynamo, although such care is not necessary in the case of a motor. This leads us to describe the arrangement of the brushes and the commutators for either motors or dynamos, and then by the aid of the diagrams of the winding it will be seen how the cutting out of the coils is effected.

Owing to the symmetrical and unvarying character of the resultant field it will easily be understood that with brushes of suitable construction it is possible to fix their position once for all, and to send out the motor with the brushes screwed down in their final position. For this purpose, in order that the point of contact may not be affected by wear, "normal" instead of tangential brush-contacts are employed, as has also been done by Mr. Holroyd Smith.

The commutator is illustrated in Fig. 3. It will be seen that it consists of two similar halves separately insulated, and each containing as many sections as there are circuits through the armature, and one of these halves is displaced through an angular distance equal to half the space of one section with respect to the other. There are then four brushes, two side by side bearing upon either half of the commutator. Its mode of action will be best understood from the diagrammatic view in Fig. 4.

This figure shows the connections of a drum-wound arma-

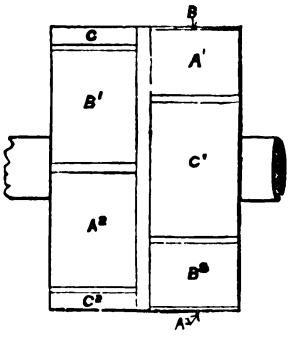

FIG. 3.

ture, having three pairs of coils, the wires being so connected that each coil is joined in series with the coil at right angles. The brushes on each half of the commutator are now connected in parallel, and in the position shown in the figure coil *a* has just been cut out, and will remain so until the armature has advanced one twelfth of a revolution. It will be seen that this double coil occupies the position *in and at right angles to* the axis of the resultant magnetic field. There are in all four connections between the coils marked A and the commutator; but upon inspection it will be found that they are all clear of the brushes. Upon the

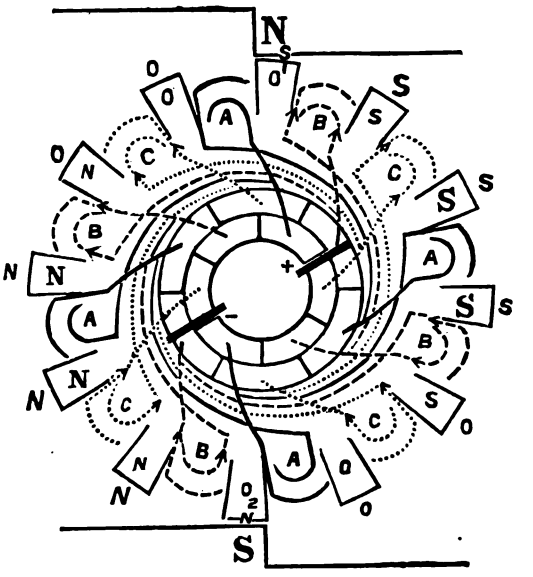

FIG. 4.—A, just cut out.

other hand, starting at the positive brushes, it will be seen that there are two paths open, one through coils B and the other through coils C. In tracing these connections, when a line terminates at the circumference it will be understood that it is to be picked up again at the extremity of the same diameter of the figure.

But this construction is open to one very obvious and equally serious objection. In cutting out the part of coil A which we wish to get rid of, we at the same moment deprive ourselves of the other half of the same circuit, which being situated

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in the magnetic axis of the field is in the very position to do most work with least deformation of the resultant field. It might seem upon a cursory inspection, and we confess that it did so seem to us, that this difficulty might be avoided by a comparatively simple alteration in the coupling of the coils. But on further examination it will, we think, be admitted that no available solution of the problem can be found, and the construction has accordingly been abandoned, while the same general principle is still retained in the improved types. The armature here figured was the one for which the silver medal was awarded last year.

(To be continued.)

NEW FORM OF STANDARDS OF E.M.F.

BY ALEX. MUIRHEAD.

Fig. 1 illustrates the mode of constructing Clark cells that has been adopted hitherto. *Zn* is a rod of pure zinc sup-

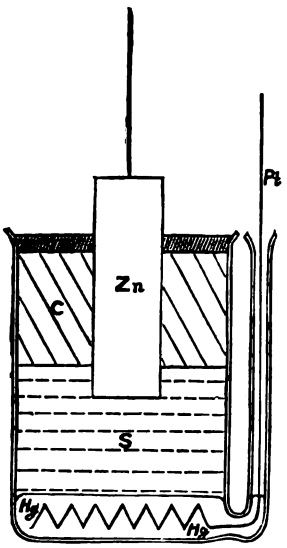

FIG. 1.

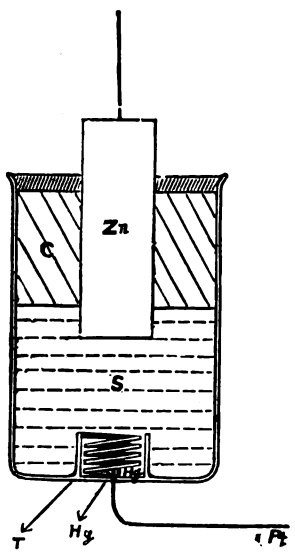

FIG. 2.

ported by means of a cork, C, in a glass cell or vessel; at the bottom of the cell is a layer of pure redistilled mercury, *Hg*,

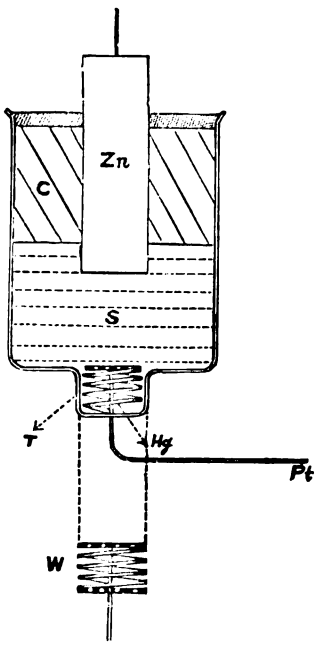

FIG. 3.

with which connection is made by means of a platinum wire, *Pt*, either hermetically sealed into the glass cell or passed down a small tube attached to the side of the cell, as in Fig. 1; between the mercury and the zinc electrodes is a paste, S, composed of mercurous sulphate (protosulphate) and saturated solution of zinc sulphate. The usual forms of the Clark cell, especially when newly set up, are unsuitable for transport; the mercury, being free, is apt to leave the platinum wire contact *Pt*, when the cell is inverted or upset, and to fall through the paste into contact with the zinc rod, thereby either short-circuiting the cell altogether or destroying the value of its electromotive force. To remedy this defect the cell is constructed as follows:—

The wire *Pt*, which may be of platinum or platinum-iridium, is coiled up in such a manner as to form a cylindrical-shaped cage, terminating at both ends in a flat or slightly-curved closely-wound spiral. This cage of platinum is fitted inside a tubular projection, T, made to the cell itself, as in Figs. 2 and 3. In filling the spiral, a quantity of pure redistilled mercury is placed in a glass cell, sufficient to cover the cage, and heated for a few minutes almost to boiling point; on cooling, the excess of mercury is poured off, leaving the cage completely filled with mercury, and the portion of the platinum wire *Pt* inside the cell well amalgamated. It is found that Clark's standard cells improved in the manner above described have the advantage of being more constant in electromotive force when subjected to vibration or rough treatment than those made according to old patterns, besides being more portable. The mass of mercury, when confined in chambers constructed of platinum in the above manner, adheres firmly to the platinum connection, and does not separate readily from it.

For most practical purposes Dr. Muirhead says that these cells form sufficiently reliable standards of electromotive force even when set up without the mass of pure mercury in contact

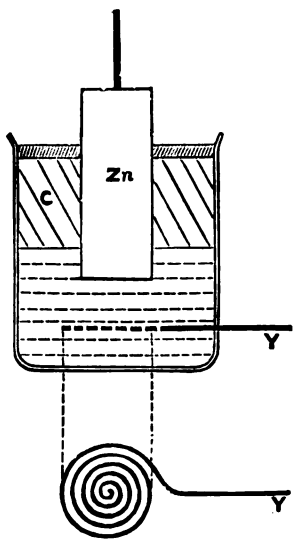

FIG. 4.

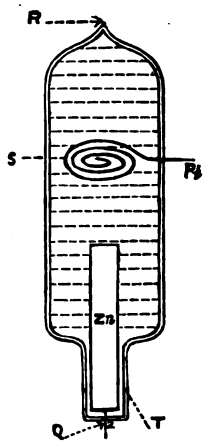

FIG. 5.

with the amalgamated platinum wire connection *Pt*. The platinum *Pt* alone answers well enough provided it is properly amalgamated with pure mercury. That is to say, standard cells with merely a surface of pure amalgamated platinum as the positive electrode, pure zinc as the negative electrode, and a mixture of pure mercurous sulphate with saturated solution of pure zinc sulphate as electrolyte, agree closely enough in electromotive force with each other for all ordinary electrical measurements.

When this mode of constructing the platinum electrode is adopted the best results have been obtained with the platinum wire wound closely into a flat or slightly curved spiral, the amalgamation being effected either by boiling it in pure mercury or by dipping it red hot into pure mercury. When platinum foil is employed, the amalgamation is more permanent if the surface be roughened or the foil corrugated or grooved. In Fig. 4 Y is a flat closely-wound spiral of platinum wire which has been coated or amalgamated with pure mercury by either of the methods above described; the continuation of the wire, *Pt* is sealed into the glass cell, forming the outer connec-

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tion. *Zn* is a rod of pure zinc supported by a cork, C, The horizontal dotted lines which have the same meaning in all the figures of the drawing represent the electrolyte used in these cells, viz., a paste composed of pure mercurous sulphate and saturated solution of pure zinc sulphate.

Fig. 5 illustrates another mode of setting up standard cells according to this invention—one which is more expensive, but more durable, than those previously shown. Instead of supporting the zinc electrode by means of a cork, C (as in Figs. 1 and 2), a platinum wire connection, Q, is fused into the zinc rod *Zn*, and sealed into the glass tube T at 2, the junction of the platinum and the zinc being protected from the electrolyte of the combination and at the same time firmly secured to the tube by shellac or other suitable cement. S is the electro-negative plate, a flat spiral of platinum wire similar to Y of Fig. 4.

The cell is hermetically sealed up at R after the introduction of the electrolytic paste of pure zinc and mercurous sulphates.

The following is a comparison of several cells of the new form supplied recently to the Eastern Telegraph Company. The comparison was made against three standards belonging to Mr. Herbert Taylor, and the readings are on the Thomson and Varley slide:—

P.	9133
Old Standard (about 7 years old)	9136·5
Cell set up by the late Mr. C. Hockin	9137
New cell—No. 1	9136·5
„ „ 2	9138
„ „ 3	9136
„ „ 4	9134·5
„ „ 5	9139·5
„ „ 6	9139
„ „ 7	9138·5
„ „ 8	9137·5
„ „ 9	9137
„ „ 10	9137·5

In Fig. 6 we illustrate a very compact and useful form of this cell. The four terminals belong to two entirely distinct

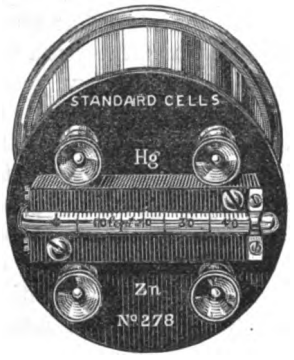


FIG. 6.

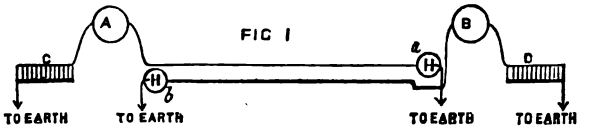
cells, the advantage being that the two cells may be used as a check one upon the other. A thermometer stands within the box, and the stem being bent at right angles lies in a groove across the top of the case, so that the temperature at the time of the reading is known.

AN "EMERGENCY SIGNAL" FOR RAILWAY TRAINS.

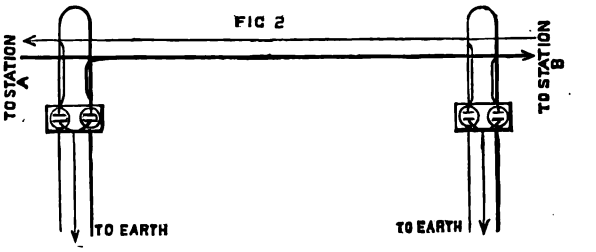
BY W. RICE AND W. SYKES.

This device is intended to give greater protection to the travelling public by establishing on the railways a series of signalling points from which the officials at the stations to the left and right can be informed of any accident or unusual obstruction. By this means the traffic of the line can immediately be stopped, and when assistance is required (as in the case of a serious collision or breakdown) such assistance can be sent with the least possible delay.

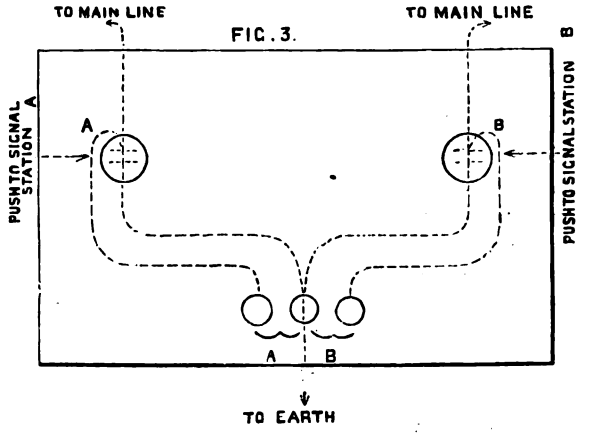
The essential portion of the apparatus is illustrated below. Let A and B (Fig. 1) represent electric alarm bells at the two railway stations or ordinary signal boxes. One pole of the motor of bell A has permanent earth connection through a battery, *c*; the other is attached to a line which terminates in a push, *a*, at station B, this push when used giving earth connection and ringing bell at A. In a similar manner the bell B is connected to earth through the battery *d*, and also to a line which terminates in a push, *b*, at station A. As thus connected, the lines serve for the ordinary signals between the two stations, each signalman ringing the distant bell by the battery to which it is connected at its own station.



But it will also be seen that with this arrangement either bell may be rung from *any intermediate point* by merely making earth connection and completing a circuit. Thus, if the guard of a train on any part of the line from A to B wishes in an emergency to signal to A, he can immediately do so by a temporary connection between the main line and the earth.



The main object of the system, however, is to establish a series of *permanent signalling stations*, from whence the guard or other persons can at once communicate with the station to the left or right. This is accomplished by fixing to the telegraph poles or other supports a series of double pushes, with short lines leading therefrom to the main lines and also to the earth, as shown in Fig. 2. The nominal position of the push of course leaves the circuit open, but the moment it is pressed earth connection is established and the signal is given.



This system may be made still more efficient by the adoption of the telephone. In this case the ordinary arrangement of the telephone company should be used at the stations, and the guard of each train furnished with a portable telephone, which he could at once connect at any of the signalling stations by means of binding screws to be fixed for that purpose.

Fig. 3 is an enlarged view, showing the telephone connections.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, *Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 *p.m.*

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THEORY IN THE WORKSHOP.

Of all the schemes propounded in recent years for the spread of theoretical and technical knowledge among the artisan classes none commends itself to our judgment so strongly as that which was tried by a leading firm of electrical engineers in the provinces last winter. It consisted of a course of Lectures delivered on the spot to the artisans and workpeople employed at the works, and students who were learning the business. The lecturer set out with a conviction, evidently shared by those who had called in his services, that the right direction for technical training is to bring home to the craftsman the scientific principles involved in daily work which passes under his hands. In other words, the firm, desiring that their servants should acquire some theoretical knowledge of the special business in which they were engaged, took the practical step of obtaining oral instruction for them, illustrated by experimental and practical applications drawn from their own workshop. There was no cramming, no examination at the end of the course, and we do not hear of any prizes. This is as it should be. The plan is not exactly new; it was adopted, if we remember rightly, by the postal telegraph authorities in respect to their operators soon after the acquisition of the telegraphs by the State; but as a solution of our technical shortcomings this is not the one which has found most favour in public estimation. Nevertheless, in the long run it will be found the one of most practical utility; and we congratulate the firm referred to on their liberality, enlightenment, and boldness in setting so good an example.

We hope that the experiment may be persevered in, and may find plenty of imitators elsewhere. It is not known to us whether the firm in question are contented with the results in this particular instance, and we do not particularly care to learn. We are satisfied that the principle is a sound one, and that even if it failed—which we do not for a moment assume—its failure would be due more to the method of applying it than to the principle itself. In some respects, we frankly confess that the Lectures chosen were not exactly what we should have supposed most needed for the object in view. They erred on the side of being too scientific. At least this is what we should suspect unless the craftsmen and apprentices addressed on this occasion were exceptionally well educated beforehand, and less in need of elementary instruction than men of their class usually are. Of one thing we are sure that the Lectures, the transcript of which has just been published in book form, are far away over the heads of average artisans, even of such as are daily employed in callings which have scientific principles underlying them. It is, we fear, too commonly supposed that this is an unavoidable necessity, and that to impart scientific knowledge the pupils must always rise to the level of the teacher, and the teacher never stoop to that of his pupils. The remarks we are about to offer are dictated by a lively sense of the untruth of this popular error, and a desire that any future lectures framed with a similar object may steer clear of the faults to which we venture to draw attention.

First, we make bold to warn all intending employers of Lecturers against such as contemplate publishing their discourses. Let us not be misunderstood. So far from meaning that these particular Lectures were not worth publishing, we assert that they are extremely valuable; anything from the pen of the distinguished author of them was sure to be so. But it does not follow that his are the sort of Lectures working men could have listened to with entire profit; and, on the other hand, it does unquestionably follow, when a Lecturer intends his Lectures for publication, he will have his final audience in his mind quite as much as, and probably more, than the simple folk whom he originally addressed. On this point some remarks in the present number of the *Quarterly Review*, which have caused a great sensation in the literary world, are not inappropriate. A few years ago, says the reviewer, a man who contributed articles to a current periodical, or who delivered a course of lectures, had as a rule the good sense to know that when they had fulfilled the purpose for which they were originally intended the world had no more concern with them, and he would as soon have thought of inflicting them in the shape of a volume, on the public, as he would have thought of issuing an edition of his private letters to his friends. So says the caustic reviewer, and he adds that nowadays every person who has figured in either of the capacities of journalist or lecturer thinks he is entitled to force himself into notice in the character of an author. Now this is not at all to be laid to the charge of our Lecturer. What, however, he may be accused of is the converse of this, namely, that being pre-eminently an author he has allowed himself to be forced into the position of a Lecturer—or, more accurately, has assumed the *rôle* of a popular lecturer with the view of publishing a volume of scientific essays.

Nothing could warrant the publishing of any course of truly popular lectures save as models of what such lectures ought to be. The more serviceable they were on delivery, the less, as a rule, are they fitted for general edification afterwards. Models in many ways, the Lectures in question, which we have read with much enjoyment, certainly are; but not of what Lectures to working men ought to be. They begin well, and for a few pages the fact is kept well in mind that the audience knows less than

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the lecturer. But soon he is off at full gallop to regions all his own, the very landmarks of which are unfamiliar and unintelligible to his hearers. His struggles between popularity and scientific accuracy are often quite amusing. At one moment he is simply stating the elementary fact that magnetism is something like sweethearting—not that the lecturer employed any illustration half so intelligible—unlike poles attracting each other; and within the next five minutes he is "strictly defining" the modes of measuring forces adopted in scientific work—the standard of mass, and the standard of length, according to the French *units* of measurement. *Dynes*, *megadynes*, *grammes*, *centimetres* and *unit poles* speedily follow, interlarded with such rudimentary truths as that if we magnetise a knitting needle we shall find magnetic poles at the ends. Nor is the necessity for the French units proved with any convincing force to a British workman's mind. The objection to the English pound, namely, that it differs at different parts of the earth, and is quite different on the earth to what "it would be on the moon," applies equally to the gramme; and as a pound avoirdupois has some meaning for a practical engineer, whereas the 453·59th part of a pound has none, he naturally declines to follow his teacher, or gives up the attempt in despair. We are not recommending that scientific accuracy, like political economy, be banished to the planets, but we are decidedly of opinion that in addressing an unscientific audience, the fact that an English pound would be short weight if carried to the moon, and all similar abstractions, might be advantageously relegated to that luminary. We respectfully, and without offensive intention, commend these observations to all persons desirous of introducing theory into the workshop.

CORRESPONDENCE.

USE OF THE TANGENT SCALE IN A GALVANOMETER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: On account of the correspondence which has recently taken place in this and other journals regarding the use of the tangent scale in a galvanometer, when the plane of the coil makes an angle with the direction of the force in the magnetic field, the following extract from Sir William Thomson's patent No. 4617, of 1883, and the accompanying remarks, may clear up some of the points that have been raised:—

"In using this instrument I sometimes cause the zero to be at one end of the scale, so that when the potential is at the prescribed definite amount, the pointer is at the centre mark of the scale of tangents. The deflections are thus more easily observed on account of the large size of the divisions."

The extract is quite explicit as to taking the zero at one end of the scale, and it is abundantly evident from the text of the patent and from the illustrative drawings that the scale referred to is a tangent scale. The essential feature in this use of the tangent scale is that the strength of the current is proportional to the difference between the tangents of the angle corresponding to zero, and that corresponding to the deflection due to the current.

The total length of the scale, as shown in the patent already referred to, and used in this laboratory for over two years, is 120°. Lately, however, the length of this scale has, with considerable advantage, been increased to 140·8°, thus giving twice the sensibility obtainable with the 120° scale.

As regards Prof. Carey Foster's letter to *Nature*, of October 7th, 1886, a tangent galvanometer arranged to use the tangent scale in this manner is essentially adapted to measure currents which flow through its own coil in one direction only, but in these instruments, as designed by Sir William Thomson, the necessary accuracy is secured by the following procedure. The index (which has a range of about 95° on each side the middle point of the tangent scale) is caused to point to a mark exactly 90° from the middle point of the scale, and the relative positions of the coil and the scale are then adjusted, so that when the index points to the 90° mark the strongest current which can be safely sent through the coil produces no sensible deflection.—Yours, &c, J. RENNIE.

Physical Laboratory, University, Glasgow,
October 16th, 1886.

THE ELECTRIC LOCOMOTIVE AND POWER COMPANY (LIMITED).

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Although I hope I may yet be spared the necessity of causing retardation of electric traction work anywhere along the line, the prospectus of the Electric Locomotive and Power Company (Limited) compels me not to remain quiescent.

The *advantages* claimed for Mr Elieson's patent by many press notices are fully described in my patent of the 31st January, 1883, and numbered 539 and 539*.

Mr. Elieson's patent is dated nearly a year and a half later than mine, viz., 6th June, 1884, and numbered 8654. I, however, do not wish the electrical world to think that I give the motor a movement of running round a table, as I should know very well that the *additional* power required for that purpose would be pure and unnecessary loss. (Enough to make all the difference probably in many cases of the possibility of competing with other methods of traction.)

I have had to give formal notice through my solicitors to the Electric Locomotive and Power Company (Limited), that Mr. Elieson's patent infringes mine. The electric field is large enough for us all—one man develops one point, one another.—Yours, &c., RADCLIFFE WARD.

10A, Great Queen-street, Westminster, S.W.,
20th October, 1886.

THE THURY DYNAMO.

Amongst the electric light installations in towns, those of Bellegarde-on-Valserine (Ain) and of the Roche-sur-Fordu (Haute-Savoie) have been reported as good examples of this class of work. The dynamos employed are of the Thury type, constructed by Messrs. Meuron and Cuénod, and are illustrated herewith. Figs. 1 and 2 show two schematic views of the

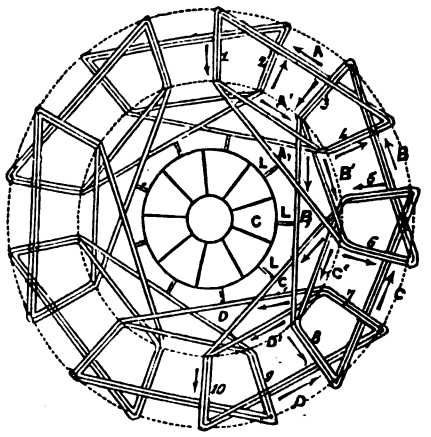

FIG. 1.

winding. The field-magnets are arranged as in Fig. 3, and consist of six electro-magnets *A A*, with massive pole pieces *pp*. The magnets are so wound as to develop alternately poles *U* and *S*. The hexagonal frame of field-magnets is fixed to the base plates B, by means of bronze supports E E on the iron base B. The armature is composed of two iron discs, K K (Fig. 4), riveted into the wood I I, upon which is wound the iron wire M, the layers of which are insulated from each other by sheets of paper. Upon the framework thus

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made the conducting wire is wound. The method of winding is shown in Figs. 1 and 2. The figures are so clear as to need little description. The figure being diagrammatic the number of turns in each coil, 1, 2, 3, is so much larger than is shown

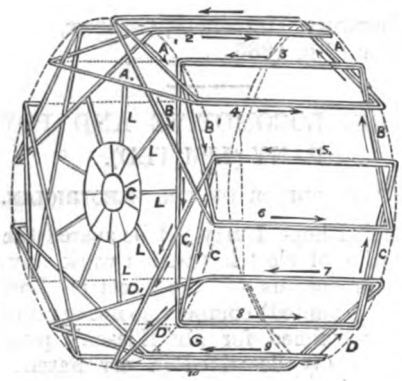

FIG. 2.

that the spaces *a*, *b*, *c*, *d*, &c. are filled with wire. The winding can be traced from *a* to *a*, *b* to *b*, throughout. The collector or commutator *c* is connected to the armature coils by the

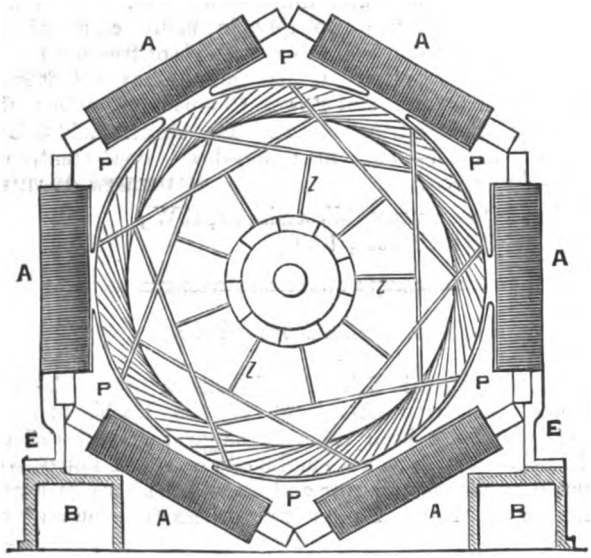

FIG. 3.

nine plates *l l*, and is similar to that of the ordinary Gramme. Its periphery is in contact with six brushes corresponding to the six poles of the field-magnets. These brushes

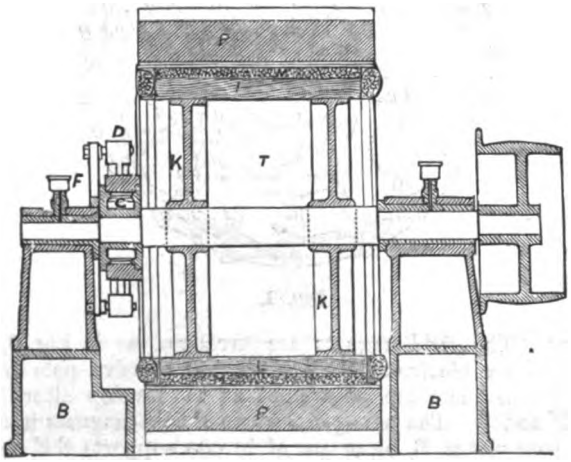

FIG. 4.

have often to be regulated separately. They are mounted on a common stud F, capable of being turned as required. This enables them to be shifted altogether without their relative angular position being varied. This disposition of the brushes renders their regulation easy, and permits of the reversing of the current in the exterior circuit when the machine is not self-excited. The brushes can be used in couples or not as required. This machine is constructed in four types of 100 volts, absorbing in ordinary work 20, 30, 60, and 100 horse-power respectively, and revolving at 600, 450, 350, and 250 revolutions, giving respectively 150, 225, 450, and 750 amperes, with an internal resistance of 0 034, 0·02, 0·009, and 0·004 ohm. The ten larger types supply respectively 600 and 1,000 sixteen candle-power normal incandescent lamps. The special characteristics claimed for this machine are—(1), the method of winding, which is said to involve the minimum waste of wire; (2), the low speed; and (3), the small internal resistance.

FURTHER NOTES ON THE FORMULÆ OF THE ELECTRO-MAGNET AND EQUATIONS OF THE DYNAMO.*

BY PROF. SILVANUS P. THOMPSON, D.SC., B.A.

1. *Frölich's simplified Formula of the Electromagnet.*

Since my former communication to the Physical Society was made, a further work on the theory of the dynamo by Dr. Frölich has appeared.† In this work he carries the simplification of the formulæ of magnet and of dynamo one stage further by introducing considerations somewhat closely connected with those which entered into my own work of 1883-4.

The form adopted by me in 1883 for the Lamont-Frölich formula was

$$H = \frac{G\kappa Si}{1+\sigma Si};$$

where H is the resulting average intensity of the magnetic field (in which the armature rotates), κ the initial value of the magnetic permeability, G a co-efficient depending upon such purely geometrical quantities as the form and size of core, pole-pieces, and coils, S the number of windings of the magnetising coil, and σ the "saturation-coefficient." This can be transformed at once to Frölich's form by writing $M = G\kappa/\sigma$; $k = \sigma$; $x = Si$. In 1884 I pointed out‡ the nature of this saturation-constant and its importance in the resulting equations of the dynamo. It is the reciprocal of that number of ampere-turns which, to mark its importance, I ventured to term "diacritical," namely *that number of ampere-turns which will reduce the instantaneous value of the magnetic permeability to half its initial value*, or which, in the formula used, will give to the magnet exactly *half its maximum magnetism*. I further pointed out in my lectures on the dynamo that year, that, if the number of windings of the coil S is given, there will be a "diacritical" current, namely a particular value of current which will exactly half-saturate the magnet. Dr. Frölich has independently made use of this conception, and has applied it to the formula of the electro-magnet. The argument is his, but I retain the notation I have used.

Writing $(Si)'$ for the diacritical number of ampere turns, we have (as I showed in 1884) $(Si)' = 1/\sigma$.

Taking the expression

$$H = \frac{G\kappa Si}{1+\sigma Si} = \frac{G\kappa}{\sigma} \cdot \frac{Si}{\frac{1}{\sigma}+Si},$$

and writing $Y = \frac{G\kappa}{\sigma}$, we have $H = Y \frac{Si}{Si+(Si)'}$

where Y is obviously the limiting maximum value of H when the excitement is infinitely great. If S is given, then i' is the diacritical current, and the expression becomes

$$H = Y \frac{i}{i+i'},$$

which is true for every electromagnet excited by a single

* Communicated to the *Phil. Mag.*, September, 1886, by the Physical Society; read June 26th, 1886.

† *Die dynamoelektrische Maschine. Eine physikalische Beschreibung für den technischen Gebrauch*, von Dr. O. Frölich (Berlin, 1886).

‡ "Dynamoelectric Machinery," first edition, p. 221; also Report Brit. Assoc., Montreal Meeting, 1884

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current. Two observations made on any electromagnet will determine the two constants Y and i'. Further, if r be the resistance of the magnetising coil, since $ir = e$ (the potential requisite to send the current through the coil), we may obviously write the equation

$$H = Y\frac{e}{e+e'};$$

where e' is the diacritical difference of potential, namely, that difference of potential which, applied to the coil of resistance r and of S convolutions, will half saturate the core.

The extreme convenience of this form of the law of the electromagnet must be at once apparent, since it enables the equation of a given magnet to be instantly adapted to the case of any given current or potential, and is equally applicable to express either the intensity of the field or the magnetic moment of the magnet. To put the matter in a more general way, let ψ represent current, or potential, or ampere-turns, and let ψ' be the diacritical value of the same for the given magnet; let ϕ be the intensity of the field, or the strength of the pole, or the magnetic moment, or the integral of the magnetic induction, and Φ its maximum value; then

$$\phi = \Phi\frac{\psi}{\psi+\psi'}.$$

This being the general equation of the electromagnet, it remains to be shown how excessively simple become the equations of the various kinds of dynamo.

2. *Equations of the Series-wound Dynamo.*

If A is the "equivalent area" of the coils of the armature, and H the average strength of the field in which it turns, the number of lines of force cut in each quadrant is AH; hence the average electromotive force at the speed n is

$$E = 4nAH. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

But $H = Y\frac{i}{i+i'}$, and, writing B = 4 A Y, and remembering that, if ΣR be the sum of the resistances in the circuit, $E/\Sigma R = i$ (by Ohm's law), we get

$$i = \frac{nB}{\Sigma R} - i'.$$

But Y being the maximum value of H, it is obvious that nB is the maximum value that E could possibly have (at that speed) even if the magnets were separately excited to saturation. Hence nB/ΣR is the maximum value that i could have if the magnets were thus separately saturated and the armature, driven at speed n, were in a circuit the total resistance of which was equal to ΣR. Adopting Frölich's notation here, we will write as $\bar{i}$ this current; and as it is important to distinguish the current generated under such conditions, I propose to call it the "maximal current."* The equation of the series dynamo now becomes

$$i = \bar{i} - i'; \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

or, multiplying each term by ΣR,

$$E = \bar{E} - E', \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

where $\bar{E}$ is the "maximal" value of E at that speed with saturated magnets. And again, writing e for the difference of potentials at the terminals of the machine, since e, multiplied by the external resistance $R = i$ under all circumstances, we have

$$e = \bar{e} - e' \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

It appears, then, that in the case of the series-wound dynamo, each of the single electrical quantities is equal to the difference between the "maximal" value which that quantity could have at that speed if the field-magnet were separately saturated and the "diacritical" value of the same quantity. This important result was announced by Frölich in 1885.

* The *maximal* current must not be confused with the *maximum* current. The latter would be obtained by rotating the armature in the saturated field at a very high speed in a circuit of resistance so small that the current did just not fuse the conductors. The *maximal* current is that obtained at speed n in circuit of resistance ΣR when the magnets are separately excited to saturation.

It may be remarked that, since we may write

$$H = Y\frac{E}{E+E'},$$

we may deduce from (1) the result

$$E = nB - E',$$

and from this derive equation (3).

It may be noted, in passing, that B is the electromotive forces that would be generated in the armature at speed = 1 if the field-magnets were separately excited to absolute saturation. It is the maximal value of E at unit speed.

3. *Expressions for the "Dead Turns."*

It is known that in every dynamo the current (with a given resistance) is not proportional to the speed, but is proportional to the speed less a certain number of revolutions per second. This latter number is known familiarly as the "dead turns." It is also known that (with given resistance) there is a certain speed below which the dynamo does not excite itself. This least speed of excitement (with given resistance) is the same as the "dead turns." It is called by some the "critical" speed; though that name is preferably reserved for the speed that is critical for self-regulation, and which is (unlike the least speed of excitation) independent of the resistance.

We can find an expression for the dead turns as follows:—

Taking the expression for the current,

$$i = \frac{nB}{\Sigma R} - i',$$

equate it to zero; the current of the machine (series-wound) being *nil* when n is reduced sufficiently to n' (= the dead turns). Then $i' = \frac{n'B}{\Sigma R}$, and

$$n' = \frac{i'\Sigma R}{B} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

It appears, then, that the dead turns are proportional to the diacritical current and to the resistance; and inversely proportional to A and Y, the factors of B. It will be noted that $i'\Sigma R = E'$, the diacritical electromotive force.

Again, we have found $E = nB - E'$; and as $E' = n'B$, it follows that

$$E = (n - n')B. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

This result is interesting in itself, and might have been used as a starting-point for the equations of the dynamo, inasmuch as it is readily found hy experiment as a fundamental relation between speed and electromotive force. Following the analogy and the nomenclature adopted, we may regard n' (the dead turns) as the diacritical speed. In other words, it is that speed at which, with magnets separately excited to saturation, the induced electromotive force will be diacritical, and will, with the given resistances ΣR, give the diacritical current. This equation (6) gives by far the best method of determining the important constant B. Two experiments to observe a pair of values of E and n will suffice to determine both n' and B.

4. *Equations of the Shunt Dynamo.*

Here we use r_s and i_s for the resistance and current of the shunt-coil, and r_a and i_a for those of the armature. We may then calculate the potential at terminals as follows. Writing $\mathfrak{R}$ for the resistance of the whole system of machine and its circuits, as measured from brush to brush*,

$$E = e + r_a i_a = e\frac{r_a}{\mathfrak{R}} = 4nAH,$$

$$H = Y\frac{e}{e+e'},$$

$$e\frac{r_a}{\mathfrak{R}} = nB\frac{e}{e+e'};$$

whence

$$e = \frac{nB\mathfrak{R}}{r_a} - e'. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

* The author's "Dynamoelectric Machinery," second edition, p. 298.

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But $\frac{nB\mathfrak{A}}{r_a}$ is the same thing as the "maximal" value of e which the machine would give, if the magnets were separately saturated, when working at the speed n through resistances as given. It may therefore be written as $\bar{e}$.

Whence, finally, $$e = \bar{e} - e' \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

From which we get at once also for the shunt current,

$$i_s = \bar{i}_s - i_s' ; \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

and for the main-circuit current,

$$i = \bar{i} - i' \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

5. *General Equation of the Self-Exciting Dynamo.*

Let ψ be any one of the currents or potentials of the dynamo, $\bar{\psi}$ its "maximal" value—that is to say, the value it has when the magnet is separately saturated—and ψ' its "diacritical value."

$$\bar{\psi} = f(n, A, Y, [R]) ;$$

and, by the very nature of the case, whatever the form of the function f,

$$\psi = f(n, A, H, [R]) ;$$

and

$$H = Y \frac{\psi}{\psi + \psi'} ;$$

whence

$$\psi = \bar{\psi} \frac{\psi}{\psi + \psi'} ;$$

and, finally,

$$\psi = \bar{\psi} - \psi' ; \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

which is the general equation of the self-exciting dynamo.

It may here be pointed out that the two terms on the right-hand side of this equation—the "maximal" and "diacritical" values of the quantity on the left—possess certain properties. In a given dynamo the "diacritical" term is a constant, whilst the "maximal" term is a variable which increases with the speed of driving. The maximal term when representing a current varies also with changes of resistance, in an inverse way, but differently in shunt dynamos from series dynamos; when it represents an electromotive force it does not vary with changes of resistance. A year ago Dr. Frölich sought to divide the equation of the dynamo into two parts—an armature part and a field-magnet part. This does not quite correspond to the case. The "diacritical" term appertains to field-magnet primarily; but since the number of ampere-turns of current that will produce a half-saturated magnetic field depends also on the quantity and quality of the iron in the machine, it is impossible to regard it as independent of the iron masses of the armature. The "maximal" term is proportional both to A, the total effective area of the armature-coils, and to Y, the maximum value of the magnetic field. The "diacritical" term for currents is lowered by increase in the number of magnetising coils, and for potentials is raised by increase in the resistance of the magnetising coils. The "maximal" term is not altered by altering the magnetising coils, but increases with an increase in the number of coils of the armature, and, for currents, decreases with increasing resistance. If the iron parts of a dynamo be given of a certain form, size, and quality, then it may in general be said that ψ' depends only on the windings (and, for currents, on the resistance) of the field-magnet, and $\bar{\psi}$ depends only on the windings of the armature (and, for currents, on its resistance) and not upon the windings of the field-magnet, or on their resistance except (and this only for currents) so far as their resistance contributes to the resistance of the whole circuit through which the current generated in the armature flows.

6. *Conditions of Self-regulation for Compound-wound Dynamos.*

In this case we write the formula of the electromagnet in terms of the ampere-turns; Si_a for the excitation due to the coils in the armature part of the circuit, Zi_s for that due to the shunt, and ϕ' as the diacritical number of ampere-turns. Then, writing

$$E = 4nAH ;$$

$$e = E - (r_a + r_m) i_a ;$$

$$H = Y \frac{Zi_s + Si_a}{Zi_s + Si_a + \phi'} = Y \frac{Zi_s + Si_a}{\bar{\phi}}, \text{ by equation (11) } ante ;$$

$$B = 4AY ;$$

we have

$$e\phi' = i_s Z(nB - e) + i_a\{S(nB - e) - (r_a + r_m)\bar{\phi}\} \quad . \quad . \quad (12)$$

The condition sought is to be such as to make e constant. Now ϕ' is a constant, so is i_s if e is, and n may be made constant at any value we please. Hence, as i_a is a variable, the condition of constancy can only be attained by giving the dynamo such a speed n_1 that the coefficient of i_a shall be zero, or that

$$S(n_1 B - e) = (r_a + r_m)\bar{\phi} \quad . \quad . \quad . \quad . \quad (13)$$

But $\bar{\phi}$, the maximal number of ampere turns, is not itself a constant, since it contains as one of the three terms in its sum the quantity Si_a. Hence we gather that absolute self-regulation is physically impossible; and it approaches to perfection as $Zi_s + \phi'$ are great as compared with Si_a. In other words, there must be so much iron in the machine that the diacritical excitement is very great, and it must have a small armature resistance; otherwise S (and Si_a) cannot be small as compared with Z (and Zi_s). This is known already to electric engineers. Assuming that the dynamo is well designed in these respects, $\bar{\phi}$ will be very nearly constant, and the equation of condition may be accepted as adequately true. This leaves equation (12) in the form

$$e\phi' = i_s Z(n_1 B - e),$$

$$\frac{e\phi'}{i_s Z} = n_1 B - e,$$

$$\frac{r}{Z}\phi' = n_1 B - e.$$

Putting in this value of $n_1 B - e$ into equation (13), we have

$$\frac{r_s}{Z}\phi' = \frac{r_a + r_m}{S}\bar{\phi} \quad . \quad . \quad . \quad . \quad . \quad (14)$$

Now ϕ' may be written either as Si_a' or as Zi_s', and $\bar{\phi}$ may be written either as $S\bar{i}_a$ or as $Z\bar{i}_s$. Choosing the second form in the first case and the first form in the second case, we may obtain

$$r_s i_s' = (r_a + r_m)\bar{i}_a ;$$

or finally,

$$e_s' = \bar{e}_{a+m} ; \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (15)$$

or the diacritical value of the potential at terminals for the shunt-wound part of the circuit must be equal to the maximal value of the potential at terminals for the armature and series-wound part. The equation (14) also gives

$$\frac{Z}{S} = \frac{r_s}{r_a + r_m} \cdot \frac{\phi'}{\bar{\phi}}, \quad . \quad . \quad . \quad . \quad . \quad (16)$$

which is more correct than the formula usually given hitherto for the ratio of the shunt and series windings, and which assumes absence of saturation terms.

The simplicity of these results, no less than that of the processes by which they are derived, lends additional value to the new formula of Dr. Frölich, whose work deserves to be more widely known and recognised than it now is.

SOUTH KENSINGTON EXAMINATIONS.

(Continued from page 269.)

HONOURS EXAMINATION.

Full marks can only be got by answering all the questions; but good answers to some of the questions are likely to gain more marks than hasty attempts to answer all of them. The value attached to each question is the same.

41. Given a sufficient length of telegraph cable consisting of a single thick copper wire uniformly covered with a cylindrical coating of insulating material, describe and explain measurements and experiments that would enable you to determine the specific inductive capacity of the insulator.

A.—Let a be the radius of the wire and l its length, and let b be the radius of insulating covering, and k its specific inductive capacity.

Then the capacity of the given length of cable will be

$$\frac{k\,l}{2\log_e \frac{b}{a}}$$

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A proof of this would not be required from a candidate at the examination, but it will be useful to give it here.

The current in the wire may be considered as an infinite straight current, so that the lines of force are perpendicular to the wire, and therefore the tubes of force are wedges whose sections are proportional to the distance from the axis, and thus where V is the potential inside the insulator, and A is a constant, we have

$$\frac{dV}{dr} = -\frac{A}{r}$$

r being measured perpendicular to the wire.

Therefore $$V = -A \log r + B$$

Now, V must have a constant value V_0 at the surface of the wire, and must vanish at the surface of the insulating material, so that writing $r=a$, and $r=b$, respectively, in the above equation, we get

$$V_0 = -A \log a + B$$
$$0 = -A \log b + B$$

which gives $$A = \frac{V_0}{\log \frac{b}{a}}$$

and therefore if σ be the surface density on the wire

$$\sigma = -\frac{k}{4\pi}\left(\frac{dV}{dr}\right)_{r=a} = \frac{kA}{4\pi a} = \frac{kV_0}{4\pi a \log \frac{b}{a}}$$

Multiplying by $2\pi a l$, the area of the surface of the wire of length l, we find that the whole quantity of electricity on that length is $$\frac{k l V_0}{2 \log \frac{b}{a}}$$

and the capacity is $$\frac{k l}{2 \log \frac{b}{a}}$$

The quantities to be measured are therefore—

(1). The length l, which may be obtained by direct comparison with an accurate scale.

(2). The radius of the wire, and that of the insulating covering, which may be done conveniently by means of a micrometer-screw wire gauge.

(3). The capacity of the given length of cable, which may be determined by comparison with a condenser of known capacity. The method selected should of course be described in detail.

42. The specific inductive capacity of the dielectric of any condenser being known, state and explain how you could determine experimentally the specific resistance of the dielectric.

A.—Charge the condenser, and connect its two surfaces with the electrodes of an electrometer. Let S be the capacity of the condenser, Q the charge on either surface at the time t, R the resistance of the dielectric, C the current in it at the time t, and E the difference of potential indicated by the electrometer at the time t.

The rate of fall of potential will be found after some time to become constant, showing that there is a steady current through the dielectric. When this occurs let the values E_1 and E_2 of E, at the times t_1 and t_2 respectively, be observed.

Now we have

$$Q = SE = SCR = -SR\frac{dQ}{dt}.$$

Therefore, if Q_1 be the value of Q at the time t_1

$$Q = Q_1 e^{-\frac{t-t_1}{SR}}$$

And therefore, if E_1 be the value of E at the time t_1

$$E = E_1 e^{-\frac{t-t_1}{SR}}$$

So that $$E_2 = E_1 e^{-\frac{t_2-t_1}{SR}},$$

Which gives $$R = \frac{t_2-t_1}{S \log \frac{E_1}{E_2}}$$

If the specific inductive capacity of the dielectric be known the value of S can be found by calculation from the dimensions of the condenser, if the latter be of simple form; otherwise by an experimental determination of the capacity of the condenser with air as a dielectric, which is a much easier observation than that of the value of S directly, since with air as a dielectric there is no electric absorption.

The value of R being known, the specific resistance can be calculated from the dimensions of the dielectric.

43. Explain fully the theory of "Wheatstone's Bridge." Describe the form of Wheatstone's Bridge with which measurements are made by adjusting a movable contact upon a graduated wire, showing what precautions and corrections are required, and how these can be made.

A.—In the Wheatstone bridge method of comparing the resistances of two conductors, four conductors, A B, B O, O C, C A, are connected, as shown in Fig. 1. The points A and O are also connected through a galvanometer, G, and a key, H, and the points B and C are connected through a key, K, and a battery, M.

In making an experiment, say, to compare the resistances of the conductors B A and A C, the battery circuit is first completed through the key K, and then the galvanometer circuit through the key H, and the resistances of the conductors B O and O C are adjusted until no deflection occurs on completing the galvanometer circuit. The resistance of B A will then be in the same ratio to that of A C, as the resistance of B O is to that of O C.

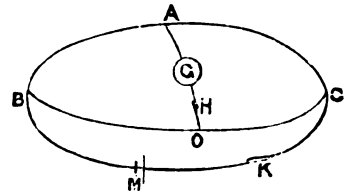

FIG. 1.

In Fig. 1 we have a system of six conductors connecting four points, three conductors meeting at each point. We might investigate the relations between the resistances of the conductors directly from Fig. 1, but the investigation will perhaps seem clearer if we draw the diagram again in its simplest form as shown in Fig. 2.

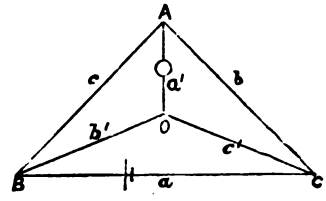

FIG. 2.

Let A, B, C, O represent the potentials of the points A, B, C, O, respectively.

Let the resistance of A B be represented by c
" " B C " a
" " C A " b
" " O A " a'
" " O B " b'
" " O C " c'

In order that there may be no current in A O the potentials at A and O must be equal. If the resistances of the conductors be so arranged that this is the case, A O may be removed without altering the distribution of currents in the conductors, and therefore without changing the potentials A, B, C, O. Considering, then, the conductors B A, A C, connecting the points B C, we see that the current through B A must be equal to the current through A C. Let x be the strength of this current. Then we have

$$B - A = cx$$
$$A - C = bx,$$
$$B - C = (b+c)x.$$

Therefore $$\frac{B-A}{B-C} = \frac{c}{b+c}$$
$$\frac{A-C}{B-C} = \frac{b}{b+c},$$

which give $$A = \frac{Bb+Cc}{b+c}.$$

By similar reasoning $$O = \frac{Bc'+Cb'}{b'+c'}.$$

In order, therefore, that there may be no current through A O due to a battery in B C, we must have

$$\frac{Bb+Cc}{b+c} = \frac{Bc'+Cb'}{b'+c'},$$

which reduces to $$bb' = cc'$$

or $$b : c :: c' : b'$$

which is the relation previously stated. In the form of Wheat-

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stone bridge with a sliding contact, the conductor B O C consists of a graduated wire of uniform thickness, so that the resistances of any two portions of it are in the ratio of their lengths. The point of contact O is made to slide along B O C until a balance is obtained, when the ratio c'/b' is read off, and therefore the ratio b/c is known.

A convenient form of a Wheatstone bridge of this construction is shown in Fig. 3, in which E F is the wire on which the sliding contact moves, and E A, A B, B C, C D, D F are thick strips of copper whose resistance is inappreciable, and which are used for making the necessary connections.

FIG. 3.

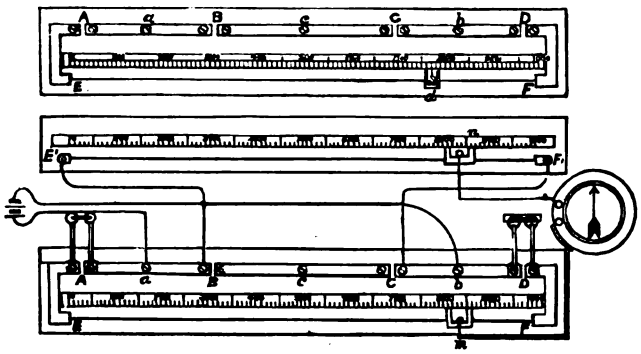

FIG. 4.

In order to compare two resistances R_1 and R_2, R_1 is inserted at B, and R_2 at C, and the gaps A and D are closed by means of thick copper strips whose resistances are inappreciable. The ends of the battery circuit (which must contain a key) are connected to the binding-screws a and b, and the wires leading from the galvanometer are connected, one to the binding-screw c, and the other to the slider d. The key in the galvanometer circuit may either form part of the slider or the contact of the slider may be continuous, and the key may be distinct from it.

The slider is then adjusted until a balance is obtained and its position is read off from the scale. If x be the distance of the sliding contact from E, and y be its distance from F, we shall then have

$$\frac{R_1}{R_2}=\frac{x}{y}.$$

The method in this form is open to the objection that a small error in reading the position of the slider generally introduces a comparatively large error into the result, and it is not easy to determine the position of the slider with great exactness. The first points, then, on which we have to fix our attention are to arrange our apparatus so that the galvanometer deflection may be as great as possible, and so that the error in determining the position of the slider may have the smallest possible influence on the result.

It may be shown that in a given system the greatest galvanometer deflection will be obtained when of the two resistances, that of the battery and that of the galvanometer, the greater resistance is made to join the two greatest to the two least of the four other resistances.

The battery must, however, never be introduced into the sliding contact, as the passage of a strong current would injure the surface of the wire at the point of contact with the slider.

In order that a given error in reading the position of the slider may introduce as small an error as possible into the result we must select a resistance R_2 with which to compare R_1, such that R_2 is as nearly as possible equal to R_1, for the resulting error will be least when the resistances to be compared are equal, and consequently the slider bisects the wire E F.

For let $x+z$ be the true value of x, and consequentiy $y-z$ the true value of y, $x+y$ being the length of the wire, and therefore constant.

Let R_1+a be the true value of R_1.

Then
$$R_1+a=R_2\frac{x}{y}\left\{1+\frac{z(x+y)}{xy}\right\}$$
$$=R_1\left\{1+\frac{z(x+y)}{xy}\right\}$$

Therefore
$$a=R_1\frac{z(x+y)}{xy}$$

For this to be a minimum $x\,y$ must be a maximum, and therefore, since $x+y$ is constant, $x=y$, or the slider must be at the middle point of the wire.

Again, the resistance of the wire E F will generally be small compared with the resistance R_1 and R_2, and therefore most of the current will flow through E F, and very little through R_1 and R_2. If, therefore, we replace the copper strips in the gaps A and D by resistance coils, we may increase the slope of potential along the wire and therefore greatly increase the delicacy with which the position of the slider can be adjusted.

In order to obtain the best arrangement, R_1 should first be determined approximately by the method already described, and the coils inserted at A and D should have resistances r_1 and r_2 respectively, as nearly as possible in the same ratio as that of R_1 and R_2.

Let a be the resistance of unit length of the wire E F. Then when a balance is obtained we shall have

$$\frac{R_1}{R_2}=\frac{r_1+ax}{r_2+ay}$$

The resistances of the thick copper strips may be neglected without much loss in accuracy, but it is of great importance that the contacts should be good, and where special accuracy is required it is better to replace the binding screws by bent pieces of thick copper, soldered to the copper strips and dipping into mercury cups.

To eliminate possible small errors due to thermo-electric couples at the junctions of different metals, a commutator should be inserted in the battery circuit, and the true position of the slider taken as the mean between the two readings obtained with currents in opposite directions.

In order to prevent variation in resistance due to change in temperature, the coils and the resistance to be determined should be placed in water baths, so that their temperatures can be ascertained, and in the case of the coils used for comparison a correction applied if the temperature observed differs from that at which they are correct.

An error may also be introduced by the unequal wearing away of the wire E F by the friction of the slider, or by accidental damage to the wire, and therefore the wire should be calibrated immediately before making important observations.

The calibration, and, at the same time the determination of the value of a, may conveniently be carried out by a method due to Prof. G. Carey Foster, and described by him in a paper in the *Journal* of the Society of Telegraph-Engineers for 1872.

Let a second graduated wire E′ F′ be connected with the bridge as shown in Fig. 4.

The gaps A and B are closed, the one by a short thick wire of practically insensible resistance, the other by a known resistance of an amount equal to that of a short length of the wire E F. This known resistance forms a gauge with which the resistances of successive portions of the wire E F may be compared.

Suppose the gauge to be at D, then the slider m is placed at or near the right hand end of E F, and the second slider n is adjusted so that there is no deflection.

The gauge and the thick copper connector are now interchanged, and the balance is restored by moving m. Then clearly the distance through which m is moved gives the length of the wire E F, whose resistance is equal to the difference between the resistance, of the gauge and connector, or, if the latter be neglected, to the resistance of the gauge. The gauge and connector may now be again interchanged, and the balance restored by moving n; and by continuing the process until m reaches the other end of the wire E F, a series of measurements will be obtained from which a table may be drawn up showing the true reading corresponding to any given observed reading E $m=x$, either by interpolation, or more conveniently by plotting the results of the measurements in the form of a curve. German silver is commonly used for the wire E F, as its specific resistance is high and does not vary greatly with the temperature.

In making measurements with the Wheatstone bridge care should always be taken to complete the battery circuit before completing the galvanometer circuit, as otherwise even when a balance is obtained, there will be a "kick" of the galvanometer needle due to the momentary self-induction current. When the resistance coils are properly wound they do not contribute to this, but there will always be some self-induction in the rest of the circuit, so the precaution mentioned above should never be neglected.

CITY AND GUILDS OF LONDON INSTITUTE EXAMINATION PAPERS.

ELECTROTECHNICS.—COURSE A.

1. Describe the process of making, adjusting, and testing a condenser.

2. Describe the condenser method of measuring the resistance of a battery, and prove the formula used.

3. Prove the equation employed when testing resistances by the Wheatstone bridge, and describe with sketches some form of "wire" bridge. What are the advantages and disadvantages of the latter in comparison with the forms in which resistance boxes are exclusively used?

4. Describe the construction of the Wimshurst influence machine.

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How does the presence of the Leyden jars affect the discharge? What is the function of the diagonal conductors?

5. Give an account of the experimental way of measuring the magnetic moment of a magnet.

6. Sixty accumulators, each having an E.M.F. of 2·05 volts and an internal resistance of ·004 ohm, are employed to light 90 glow lamps. Each lamp requires 0·64 ampere of current. The effective resistance of the leads is 0·226 ohm. Find what percentage of the whole work done by the battery is utilised in the lamps, and what potential difference is employed to run them.

7. Give the definitions of "unit magnetic pole," "unit intensity of magnetic field," "one dyne," "the absolute unit of strength of current," "one ohm," "one farad."

8. Find the resistance of a copper telegraph wire 83 mils. in diameter and 54 miles long, having given that the specific resistance of copper at 0°C. is 1·57 microhm. What is the resistance of this wire at 35°C. if the temperature coefficient be ·0038?

9. Describe the Latimer Clark standard cell, and the precautions to be observed in making and using it. How can the Daniell cell be converted into a standard cell?

10. Describe the "sine" method of relatively calibrating a galvanometer; why cannot it be used for deflections beyond a certain limit. How would you convert your *relative* calibration into an *absolute* one?

ON ELECTROLYSIS.

BY PROF. OLIVER J. LODGE, D.SC.

(Continued from page 398.)

Theory of Kohlrausch.—The fundamental assumptions underlying the beautiful theory of Kohlrausch are the same as those adopted by Wiedemann. He considers electrolytic conduction performed by dissociated atoms, each of which carries the same numerical charge of electricity, one set positive the other set negative. He follows Quincke in considering their motion due and proportional to the slope of potential $\frac{dV}{dx}$; and he accounts for migration by unequal speed of travel. But—and this is the special Kohlrausch idea—every ion is supposed to have a specific velocity, in a given fluid, when urged by a given slope of potential; a velocity wholly independent of all other circumstances. Moreover, all very dilute solutions are found to behave similarly, so that an ion's rate of travel is nearly independent of the nature of the dissolved substance so long as there is not sufficient of it to interfere with the general aqueous nature of the liquid. Kohlrausch has further shown how to calculate this specific ionic velocity in absolute measure, from conductivity, concentration, and migration data. And the following table, taken from Clerk Maxwell's "Elementary Electricity," embodies some of his results.

Specific Velocity of different Ions in centimetres per second when urged in a very watery solution (i.e., *one whose viscosity differs very little from water, no matter what acid or salt is being electrolysed in it) when urged by an E.M.F. of one volt per centimetre: according to Kohlrausch.*

Cations:	H	K	Am	Na	Li	Ba	Sr
	·0029	·00051	·00049	·00032	·00020	·00033	·00030
			Ca	Mg			
			·00025	·00022			
Anions:	I	Br	Cl	F	N_2O_3	Cl_2O_3	$C_2H_3O_2$
	·00058	·00056	·00053	·00031	·00050	·00038	·00023

It is only with much misgiving that I venture to criticise so admirable a theory supported by close agreement with experiment; but it seems less dangerous to hesitate unduly over a true theory, than to accept too hastily a false one. In the expectation that the objections I urge against the entire and comprehensive truth of this doctrine of specific atomic velocity will be speedily met and shattered I proceed to state them. In the first place I proceed to draw a radical distinction between the *sum* of the velocities of opposite ions and their individual velocities. Even if we admit provisionally that the sum of anion and cation velocities can be calculated from conductivity data, I demur at the partitioning of this velocity u into two unequal portions and affixing a definite velocity to either ion. The only data existing for such apportionment of u, into nu and $(1-n)u$, are the migration data of Hittorf; and I have shown at some length that all the observed facts may be otherwise explained, I even venture to think, *must* be otherwise (or to some extent otherwise) explained. But, passing over this point, there are doubts about the sufficiency of our present data for u itself. The Kohlrausch theory considers the dissolved salt as the sole electrolyte; it neglects the conductivity of the water.* Let us therefore start *ne novo* and independently.

Attempt at Calculation of absolute Ionic Velocity.—Let n equal the number of dissociated molecules *of the substance undergoing decomposition* in a liquid, per unit length. Let q equal the total charge (reckoning + and − together numerically), and m the mass of each molecule; and let u be the relative velocity of opposite ions with respect to each other, under the influence of a propelling force $\frac{dV}{dx}$.

Consider an element $dxdydz$. The number of active molecules in its face is n^2dydz, the number leaving it per second is $n^2dydz \cdot nu = n^3udydz$. The quantity of electricity thus conveyed is qn^3udydz per second, and the corresponding amount of travelling matter is mn^3udydz per second, so that the electrochemical equivalent of the substance is $\epsilon = m/q$. By Ohm's law the strength of current is $k\frac{dV}{dx}dydz$, where k is specific conductivity of the solution; hence, since the current is also the quantity conveyed per second,

$$k\frac{dV}{dx}dydz = qn^3udydz,$$

or

$$u = \frac{k\frac{dV}{dx}}{qn^3} = \frac{\epsilon k}{mn^3}\cdot\frac{dV}{dx}.$$

But mn^3 is the number of grammes of the electrolysed or dissociated substance in a unit cube, and this we may write $N\mu$, where N stands for the number of monad gramme-equivalents of the really electrolysed substance per c.c., and μ is its molecular weight compared with hydrogen. Moreover $\frac{\epsilon}{\mu}$ is simply the electrochemical equivalent of hydrogen, *i.e.*, a constant, say η; so

$$u = \frac{k}{N}\cdot\eta\frac{dV}{dx}.$$

We see, then, that for a given slope of potential u varies only with $\frac{k}{N}$ or, as Kohlrausch would put it, with conductivity ÷ concentration, which latter he has proved within certain limits to be nearly constant for many salt solutions.*

But the question now arises, is N really simple concentration? What is the substance really undergoing electrolysis? Kohlrausch considers that in weak saline or acid solutions it is the dissolved salt or acid only, and he appears to consider that every molecule of this is effective; hence he would say N is at once determined by knowing how much stuff has been dissolved per litre. Take, for example: A 5 per cent. solution of ammonic chloride contains about ·001 gramme equivalent of the salt per c.c. (*i.e.*, say 53 grammes per litre); and it has a conductivity about 9×10^{-6} that of mercury at 0°, or say 10^{-10} absolute units. The E.C.E. of hydrogen is 10^{-4}; so then we can easily calculate the sum of the ionic velocities for the AmCl molecule in such a solution, *on the hypothesis that it is the sole effective compound present, and that the whole of it is effective*—

$$u = \frac{10^{-10}}{10^{-3}}\cdot 10^{-4}\frac{dV}{dx} = 10^{-11}\frac{dV}{dx}.$$

Let the slope of potential be one volt per centimetre, *i.e.*, let $\frac{dV}{dx} = 10^8$, then $u = ·001$; and this agrees exactly with Kohlrausch's value; only he apportions it ·00049 to Am, and ·00053 to Cl, upon Hittorfian grounds, instead of half to each. Ignoring this last mere migration question, what is there hypothetical about the arithmetical problem? Plainly the nature of the substance conveying the current; *i.e.*, the value of N.

If what I have said under the head "migration" has any weight, the current is really conveyed partly by the dissolved substance and partly by the solvent, in the proportion of λ to $1-\lambda$. Let us reconsider the above investigation from this point of view. Very little change need be made; we shall have n_1^3 and n_2^3 for the number of dissociated molecules of the two substances per c.c., and u_1 and u_2 for their respective ionic velocities. The ratio in which the two substances conduct the current will be $n_1^3u_1$; $n_2^3u_2$; and corresponding to n_1^3 and n_2^3, there will be N_1 and N_2 to represent the amount of dissociated substance present, reckoned in gramme-equivalents per cubic centimetre of solution; but q remains of the same value as before and equal to $\frac{N_1}{\eta n_1^3}$ or $\frac{N_2}{\eta n_2^3}$.

So the equation between two expressions for intensty of current becomes

$$k\frac{dV}{dx} = q\,(n_1^3u_1 + n_2^3u_2) = \frac{q}{\lambda}n_1^3u_1;$$

or

$$u_1 = \frac{\lambda k}{N_1}\cdot\eta\frac{dV}{dx},$$

and

$$u_2 = \frac{(1-\lambda)k}{N_2}\cdot\eta\frac{dV}{dx}.$$

The value of λ is determined by migration experiments, in the way already explained, and k of course is known; but, since there exists no known means of ascertaining the value of N_1 and N_2, there remains complete uncertainty as to the values of u_1 and u_2; all that one can determine, from conduction and migration data combined, are the values of N_1u_1 and

* In the January (1886) number of *Wiedemann's Annalen*, Prof. Kohlrausch gives a long account of his present standpoint. In sec. 20 he discusses this question of the conductivity of water, and sees reason for modifying his original view, and for admitting that in very dilute solutions water does share in the electrolysis. He mentions, what I did not know, that part-conduction by water had been suggested by Prof. Clausius as accounting for migration; but Prof. Kohlrausch himself adheres to his old Hittorfian view of it.

* Kohlrausch's latest statements make k/N (understanding N in his sense *pro tem.*) a linear function $\sqrt[3]{N}$, *i.e.*, of the distance between molecules; but the plotted lines showing this are after all very curved, and all that the facts really amount to is, I think, that

$$k = a + bN + cN^2 + \&c.$$

where a being the conductivity of pure water, may be taken as zero. The N here interpreted in Kohlrausch's sense, as representing the amount of dissolved salt, I call henceforth N′.

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of N_2u_2. On Kohlrausch's hypothesis, taking the suffix 1 as applicable to dissolved salt, λ is supposed to be 1 and u_2 accordingly 0; moreover, since *every* molecule of the salt is supposed by him to be dissociated sufficiently to take part in the conduction, N_1 is considered known from concentration data, *i.e.*, from the percentage of salt contained in the water, and thus u_1 is calculable. Permitting ourselves to doubt all this, we come to the conclusion that we do not yet know the absolute velocity of any ion, and cannot know it without further information regarding the dissociation ratio (that is, N_1/N', or N_2/N') of each substance present. On the unlikely supposition that this criticism be in any sense accepted, what is the meaning of the striking agreement between Kohlrausch's theory and experiment? His view leads to the equation

$$k\eta\frac{dV}{dx}=N'u,$$

where N′ is the total number of monad gramme-equivalents *of the dissolved substance* in a cubic centimetre of solution. Our view, on the other hand, leads to the equation

$$k\eta\frac{dV}{dx}=N_1u_1+N_2u_2,$$

where N_1+N_2 represents the (unknown) amount of *actually conducting substance* per c.c. of solution.

Now it seems by experiment that k/N' is an approximate constant,* at any rate for weak solutions; so we must suppose the fact to mean that $N_1u_1+N_2u_2$ is, within limits, nearly proportional to N′.

It is in no way surprising that the dissociation of both substances should proceed *pari passu* with, and be initially proportional to, the quantity of stuff added to the water; but there remains a further question, which, if I am able to discuss it, shall be considered elsewhere.

Theory of von Helmholtz.—Finally we come to the wide-reaching theory of Helmholtz.

The root idea of this theory is that each kind of matter has a specific attraction for electricity, some kinds for positive, other kinds for negative; that, accordingly, work must be done to separate an atom from its electrical charge, or to remove electricity from an atom of high specific attraction and give it to another lower in the scale. Further, that chemical affinity is mainly due to the electrical attraction of oppositely charged atoms, and that when such atoms combine into a compound molecule they do not discharge into each other, but retain their charge.

Apply this principle to a Daniell cell.

During the action of the cell a certain amount of positive electricity has to leave (deposited) Cu, a substance which attracts it feebly, and enter into union with (dissolved) Zn, a substance which attracts it much; hence is derived the energy or E.M.F. of the cell.

Apply the same principle to a water voltameter. During the passage of a current the charges are torn from hydrogen and oxygen atoms and given to the electrodes, which, if they are platinum, have no special attraction for either electricity; hence arises the E.M.F. of polarisation, or the work needed to decompose the liquid. Work is done, according to this theory, not in tearing the atoms asunder, but in tearing their electric charges from them. If the ions are allowed to enter into combination with some available radicles, in such a way as to retain their charges, polarisation E.M.F. is much reduced. So long as the atoms have not given up their charges they cling to the electrodes and cannot be removed mechanically, say by exhaustion or the like; but if once their charges are given up and molecules of the single substance formed, it makes but little difference to polarisation whether that substance be allowed to dissolve in the liquid or be made to bubble up from it. But it is to be understood, I believe, that in estimating E.M.F., or effective energy of a cell per unit electricity conveyed, Helmholtz would take into account the energy of all secondary, as well as of all primary actions, "minor attractions of solvents" as well as affinities of iron.

Helmholtz points out that the interior of an electrolyte cannot stand the slightest electrostatic strain, and hence, in so far as a voltameter behaves as a condenser, it does so by reason of actions going on within the films or boundaries separating the liquid from the electrodes. From observations made with his air-free cell Helmholtz estimates the thickness of these quasi-dielectic films as 10^{-8} centimetre—the customary molecular magnitude.

It seems to me that Helmholtz accepts the possibility that ordinary electrostatic laws may be applied to the interactions of atoms and their charges, and to the attractions of atoms by the electrodes across this thin molecular film. And he points out that the reason so feeble an E.M.F. is sufficient to effect decomposition is just because of the extreme thinness of the film—the slope of potential dV/dx being by no means insignificant.

Helmholtz shows that the analogue between the pre-decomposition state of a voltameter and a condenser of constant capacity is accurately sustained by his air-free cell, charge being proportional to potential down to $\frac{1}{1000}$ volt or perhaps lower; and this fact he considers to prove that by far the greater part of the force binding atoms together, and probably the whole of it, is electrical; for "if any chemical force bound ions together, requiring work to overcome it, an inferior limit ought to exist to such E.M.F.'s as are able to attract ions to the electrodes and charge them as condensers. No indication of any such limit has yet been discovered."

But while he thus considers it proved that the mightiest chemical forces are really electrical, he by no means denies the existence of others. Atoms cling to electricity, and charged atoms cling to one another, but uncharged atoms may cling somewhat, and this may be the distinction between "typical compounds" and "molecular aggregates." This distinction had been forced upon me also independently, and so I quote it with full agreement. All electrolytes belong to the "typical compound" class, and it is by means of the charges in these atoms that they are so easily decomposable, notwithstanding their strong affinities. But combination can occur between elements of very weak affinity, which only with difficulty can be got to unite; and yet, once combined, they seem to cling with the most surprising tenacity. These bodies, I should suppose, are molecular aggregates held together by purely "chemical," *i.e.*, material or non-electrical, forces; and the reason of their apparent tenacity is, I would suggest, merely that they afford no handle to lay hold of. They are quite unsusceptible to electrical influence, unless it be in the violent and perhaps thermal form of the electric spark. If I instance such bodies as cyanogen and ammonia it is only to indicate more suggestively what I mean.

I do not feel sure whether Helmholtz would lend his name to the suggestion just made, for he hedges a little about these molecular modes of combination, and says: "But the fact that even elementary substances with few exceptions have molecules composed of two atoms makes it probable that even in these cases electric neutralisation is produced by combination of two atoms each fully charged, not by neutralisation of every single unity of affinity." I venture with great deference to suggest, as an objection to this view, the fact that charged (say hydrogen) atoms are unable to unite with each other, though they attack everything else with vigour, but that so soon as they are allowed to give up their charges to an electrode they at once unite and become molecules of gas.

I need not stay to do more than remark that the notion of an attraction between matter and electricity is made by Helmholtz to explain a great many other things—"contact E.M.F.," "thermo-electricity," "frictional electricity," and, in fact, all electrostatics and most of current electricity. These things appear in a great many of his writings, first in his great Memoir of 1847, but they are conveniently summarised in his Faraday Lecture of 1881, from which I have just now been quoting.

It is scarcely decent to obtrude my own opinion on so fundamental a subject as this, but I may be permitted to say that if one does grant such an attraction, and if one further conceives positive and negative electricity as the two constituents of ether, not only chemical affinity but specific inductive capacity and refractive index, together with the Fresnel-Fizeau connection between ether and matter, can be readily conceived, and, so to speak, accounted for; and the attraction of gravitation does not lag far in the background. Seven years ago I spent some time endeavouring to set out all these things in a systematic and pretentious form, but I came to the conclusion that the task was beyond my strength. The special things which Helmholtz more particularly explains by his theory—viz., contact E.M.F., thermo-electricity, and frictional electricity—did not suggest themselves to me in such a direct connection with it; nor do they now.

The theory of Helmholtz insensibly impels one to try to apply ordinary electrostatic considerations to the interactions of atoms and to the effect of electrodes upon them. It suggests, in fact, a theory of chemistry; in the form of a sort of supplementary kinetic theory of gases with electrified atoms. But the liquid state, which (more than ever by recent researches*) seems essential to chemical action, has difficulties of its own to be overcome before the behaviour of electrified atoms can be properly treated.

It may be noted that whereas the actual force of attraction between two atoms at a distance like 10^{-9} is not great, being something like 10^{-4} dyne, the acceleration produced by it in the small mass of an atom is terrific, being nearly a trillion times that produced in ordinary bodies by the earth. To show that mechanical forces are insignificant compared with electric ones between charged atoms, Helmholtz reminds us that their electric attraction at any distance exceeds their gravitative attraction at the same distance nearly a hexillion times.†

* See, however, a previous footnote.

* Those of Mr. Dixon and others on combustion and on gaseous combination or explosion. As Prof. Armstrong has pointed out, they seem to suggest a necessity for the presence of a dissociated typical compound, *i.e.*, for electrically charged atoms (see above), in every reaction. Should this turn out to be a fact, it will be one of profound chemical and physical interest.

† This is not exactly Helmholtz's way of putting it (Faraday Lecture, 1881), but it comes to the same thing; and it is perhaps as well to notice that there is nothing uncertain about the calculation; the least accurately known datum in it is the gavitation constant, or the earth's mean density. The general expression for the ratio between the electric attraction of two radicles in an electrolytic compound and their gravitative attraction, at any given distance, is

$$\frac{V^2}{4\gamma\mu_1\mu_2\eta^2};$$

where V is the velocity of light, η the electro-chemical equivalent of hydrogen, γ is the gravitation constant, $g\mathrm{R}^2/\mathrm{E}$, or $\frac{3g}{8\rho\times10^9}$ while μ_1 and μ_2 are the combining equivalents of the radicles in the compound compared with hydrogen; or $\mu_1+\mu_2$ is the compound's ordinary "molecular weight" divided by its "atomicity"; *e.g.* for water, $\mu_1\mu_2=8$; for copper sulphate, 80; for silver nitrate, 6696.

The numerical value of the above ratio is

$$\frac{10^{36}}{3\mu_1\mu_2}$$

(To be continued.)

CAOUTCHOUC FROM A EUROPEAN HERB.—According to the *Bulletin de la Société Chimique de Paris*, a plant belonging to the lettuce tribe, scientifically known as *Soachus Oleraceus*, and quite common on the wayside and among dry rubbish heaps in France, has been found to yield a very good quality of caoutchouc. The plants are steeped in carbon bisulphide, and afterwards boiled in alcohol and caustic potash. About 4·3 per cent. of the weight is thus obtained as caoutchouc.

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COMPANIES' MEETINGS & REPORTS.

Direct Spanish Telegraph Company (Limited).

An extraordinary general meeting of this Company was held at Winchester House, 50, Old Broad-street, London, on 19th inst., under the presidency of Sir James Anderson, to consider the confirmation of the resolutions passed at the extraordinary meeting on the 30th ult. for reducing the capital of the Company.

The MANAGER (Mr. Ch. Gerhardi) read the notice calling the meeting.

The CHAIRMAN in opening the proceedings announced that Mr. Bannatyne had intimated his intention of taking legal proceedings against the proposed scheme being put into execution. He also regretted to say that he had received other protests, representing in all thirty-seven shares, while, on the other hand, in favour of the proceeding they had proxies from ninety shareholders. At the last meeting Mr. Baker was the only proprietor who, in the opinion of the Board, presented any specific arguments against the Directors' action, or any specific arguments which the Board could answer. Mr. Baker had a right to be seriously considered, because he was a man who naturally understood the class of business before them, and he must have had many examples to put before them. The Directors therefore had naturally very carefully considered everything which that gentleman had said, especially after the meeting. Mr. Baker said, Why not wait for ten years, and then the preference shareholders will get the whole of the arrears, and begin with a 10 per cent. dividend after ten years? In his (the Chairman's) opinion that view had influenced some of the shareholders, and it was plainly seen that it had some weight. But a little consideration would show the shareholders that at the end of 10 years the preference shareholders would get no arrears at all. All the arrears of the £5,000 lying by would go naturally to recoup the capital lost, so that if the capital remained intact, as it now was, at the end of 10 years the preference shareholders would get 7 per cent. only and no arrears whatever, and the ordinary shareholders of course would get nothing, but would have to look forward to something like 40 years before they could get anything unless the debentures were paid off with the arrears. If that were done the preference shareholders would begin to get some of their arrears. But still the ordinary shareholders could look forward to nothing. That was the position they were now in. Would they go on for 10 years and get nothing at all till that time, or would they now take 2 per cent. less than they would get then and begin to get a dividend now of £2. 10s. per share of arrears paid down? That was the position they were in. The Directors had no possible object in doing anything but making the Company a living concern; and it could not benefit them or anyone belonging to them to do anything other than endeavour to make the Company a live instead of a dead horse. Another shareholder at the last meeting, after the proceedings were over, made a suggestion which the Directors had not failed to consider. He saw that it was before them again that morning by the broker who had got the protesting 37 shares. The suggestion was, Why not, after the shareholders get, say 5 per cent., divide anything above that between the preference and the ordinary shareholders? That point had not escaped the Directors, but it had to be remembered that in all these 13 years the ordinary shareholders, who found the bulk of the capital for the Company, had received only 19s. 11d. per share dividend, and as for their getting above 5 per cent. in the time to come, that would all depend on what was going to happen in 10 years with the existing cable. If the existing cable remained intact, and they were going to have an improving revenue, then they might talk of dividing what might accrue above 5 per cent. between the preference and the ordinary shareholders. They did not, however, know what would happen to the cable in 10 years. They had allowed for the yearly £5,000 reserve, but there was nothing whatever for war risks or contingencies other than very ordinary contingencies for repairs, so that it might easily happen in 10 years that the preference shareholders even would not get 7 per cent., while of course the ordinary shareholders would get nothing. The Directors had no object whatever except to make the Company a paying concern, and there was no reason for anybody to say otherwise. Unless the Directors had the shareholders' support, it would be naturally very difficult to carry it through, and the law might say that they should not do so. That, however, would be proved. Mr. Bannatyne might get his object in opposing them, whatever that object might be, but if it was to get more than the Directors' scheme offered, he thought the chances of that were very remote. He concluded by moving the following resolution:—"That the two resolutions passed as special resolutions at the extraordinary general meeting of the Company held on the 30th September last be, and the same are hereby, confirmed."

Mr. ETLINGER seconded the motion.

Mr. COCHRAN said that the statement of the Chairman was not sufficiently clear to satisfy him. He had understood, before coming to that meeting, that the Chairman was going to make a statement which would convince all reasonable men that the proposal made by Mr. Baker at the last meeting would not work, and that the preference shareholders would not get their 10 per cent. He wished that the Chairman would state the premises on which he had arrived at that conclusion.

The CHAIRMAN, in reply, said that Mr. Baker's objection to the Board's scheme was based on the proposition that it would be more advantageous to the preference shareholders to wait ten years and then receive £10 per share for arrears of interest and 10 per cent. dividend afterwards, rather than accept the Board's scheme of £2. 10s. per share for arrears of interest at the end of this year, and 10 per cent. dividend from that date upon the reduced capital. This proposition, however, assumed the position of affairs to be quite different from the actual position, which was as follows:—At the end of ten years the lost capital would be recouped, and that money would remain in hand as an asset representing the abandoned cable; but there would be no funds wherewith to pay any arrears whatever of preference dividend, and when the payment of the preference dividend was resumed after the ten years it would be at the rate of about 7 per cent., and not 10, unless the income of the Company were materially to improve. Assuming the accuracy of the financial statement already made of an average net revenue of £12,750 a year, there would be reserve for renewal of cables of £5,000, and interest to pay on debentures amounting to £3,720. That would leave £4,030. It therefore followed that the present preference capital of £60,000 could only receive a bare 7 per cent. dividend. The question arose as to the use to be made of the £60,000 accumulated at the end of ten years. If a new cable were laid it would be necessary to make provision for its maintenance, say, £2,000 put to the reserve. That would reduce the £4,030 and leave for the preference shareholders only £2,030, or about 3½ per cent. dividend. If it should be found possible to do without a new cable, then the £60,000 could probably be best employed in redeeming the Company's debentures (which paid for the existing new cable of 1884). Interest to the extent of £3,600 would be saved, which, added to the £4,030, would leave £7,630 for the preference shareholders, or sufficient to pay them the 10 per cent. dividend and £1,630 towards arrears of interest. That assumed that they laid no other cable, that the cable in existence now remained intact, and required no outlay of the capital now lying by—assumed, in fact, what was improbable, and what no one knowing anything of such a matter would conceive. The total arrears in the year, say, 1898, would be £75,000 (arrears to pay off) and it would take forty-six years before all the arrears would be paid. It was, therefore, only in the year 1944 that all the arrears would be paid, and not in 1898, as Mr. Baker suggested. With these facts before them it was for the shareholders to decide whether they would support the Directors in their endeavour to restore the Company to the position of a dividend-paying concern, or allow it to drag on in its present non-dividend-paying state.

Mr. BANNATYNE said that notwithstanding all that the Chairman had stated, his (the speaker's) conviction was, if anything, stronger than ever that as regards the preference shareholders the scheme proposed by the Directors was illegal, unfair, and unjust. He intended, however, as far as that meeting was concerned, merely to vote against the confirmation of the resolution. Sir James Anderson had made an allusion as to what his (the speaker's) object might be. It was simply to prevent a great injustice being done to the preference shareholders. He differed altogether from the Chairman's statement that there was no other way of improving the position of the Company. Why did not the Board have a conference with both the leading preference and ordinary shareholders?

The CHAIRMAN: Have you any plan?

Mr. BANNATYNE: Yes.

The CHAIRMAN: Will you favour us with it?

Mr. BANNATYNE said that he was not bound to do so. Let the resolutions be withdrawn first, and then let the shareholders be called together to consider the best plan.

The CHAIRMAN said that Mr. Bannatyne had talked about legality and justice; but where was the justice or the legality of Mr. Bannatyne in forming another company when he was chairman of that Company? And where was his sense of justice in speaking in the tone he had of the Directors' plan? Mr. Bannatyne had some other object.

Mr. BANNATYNE repeated that he had not.

Mr. LOWE: It is to smash up the company, as I said at the last meeting.

The CHAIRMAN, continuing, said that it was for the Court to decide whether what the Board proposed was illegal. It was open to Mr. Bannatyne, while Chairman, to propose any plan for making the company a going concern; but he had not done so. In answer to a shareholder, the Chairman added that the concessions held by the Company did not give them a monopoly. The proxies were not sent out at the expense of the Company.

The SHAREHOLDER, who said he was trustee for a widow lady, afterwards proceeded to express objection to the Directors' proposal, contending that it was unfair to cut down the preference and ordinary shares alike, and that greater consideration should be shown to the preference shareholders.

Mr. COCHRAN said he felt bound to vote against the resolution, as the statement of the Chairman did not appear to him as at all conclusive. If they approved of the scheme proposed it seemed to him that they would be open then to the same difficulties as had been referred to, for the risks and all the other accidents to which the cable was exposed would equally affect them and would equally cut away the revenue from which their dividend had to be paid. He thought in any case that the shareholders would have acted more in their own interests if they had adopted the suggestion made at the last meeting to adjourn that meeting with the view to holding a conference. He did not want to attack the Board, but Sir James Anderson was a Director of the Eastern and of the Globe Companies, both of which were largely interested in the shares of the Direct Spanish Company. If the business went on in the ordinary way the ordinary shareholders would, he contended, get nothing; but by the altered circumstances proposed they would participate largely in the revenue. Moreover, it was the ordinary shareholders' money that was lost, the preference capital having been raised to buy the cable which was now working and earning money.

The CHAIRMAN observed that he had answered that point at the last meeting, and Mr. Cochran was not stating the matter properly.

Mr. COCHRAN said he had seen the resolution for raising the preference capital, and it asked for powers to buy the cable in question (which cost £45,000), and for other purposes.

The CHAIRMAN: For other purposes.

Mr. COCHRAN maintained that the principal object was to buy the cable.

The CHAIRMAN, in reply, said that Mr. Cochran seemed to forget that

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the preferred and the ordinary shareholders were partners in a business which had lost so much of its capital. That was the basis the Directors were going on; and as he understood the law, there must be a *pro rata* suffering on the part of the proprietors in wiping off the lost capital, or in doing something to reinstate it. Mr. Cochran had repealed his attack because he (the Chairman) was a Director of the Eastern and the Globe Companies, but the former had all ordinary and the latter all preference shares. He was an anxious Director of both those companies, as he was of this Company, which he desired to be made a living concern. That was the sole desire of the Directors, and if the shareholders did not let them carry it out they must remain as they were, unless some other acceptable proposal could be made.

The motion was then put, and carried by 14 against 5.

The CHAIRMAN, in answer to Mr. Burt, said that the Directors would gladly receive and consider Mr. Bannatyne's plan.

Mr. BURT said it was very easy to find fault with other people's plans, but difficult to suggest others. If Mr. Bannatyne at the eleventh hour would put before the Directors a scheme which he considered more just and legal, the Directors would give their careful consideration to it, and, if necessary, invite the shareholders' acceptance of it. It was not too late yet, because the Directors' scheme was not carried. He did not think the shareholders would attach too much importance to what was complained of in one scheme if no suggestion for improving it were made.

Mr. BANNATYNE said that the the first intimation he had of the Directors' plan was three days before the meeting, on his return to town.

The CHAIRMAN: It is a fortnight since then.

A SHAREHOLDER: Three weeks.

Mr. BANNATYNE: Call it three. Continuing, he said he was not bound to consider another scheme in opposition to that of the Directors, but he was perfectly willing to do so with any of the shareholders or Directors. He could not be expected to bring forward a plan without sufficient time to consider the matter and prepare a plan, because it was of great difficulty, as he was quite aware.

The CHAIRMAN: You were here for 11 or 12 years. Mr. Baker gave us a plan in five minutes. If you have any plan for consideration we will pause and call another meeting after this; but we have our legal adviser who says within what lines we must go, and we have Articles of Association, and everything has been taken into consideration. If there is nothing but vague talk there is no use trying to argue it.

Mr. COCHRAN said he wished to propose a vote of thanks to the Chairman and Directors. He had criticised them, but he was satisfied that they were in a very difficult position. He thought it would not be in good taste on the part of Mr. Bannatyne, unless he had something substantial to propose, to land the Company and the unfortunate shareholders in law costs. He would therefore take the liberty of suggesting to Mr. Bannatyne, unless he had something to propose that could be carried out legally, that it would be wise to pause.

The resolution was seconded and carried.

On the motion of Mr. COCHRAN, seconded by Mr. WALTER PUCKLE, a resolution was passed unanimously "That unless a tangible and practical scheme can be formulated in substitution of that of the Directors, the shareholders deprecate an appeal to law, as being expensive and useless."

The proceedings then terminated.

Eastern Extension Australasia and China Telegraph Company.

Report and accounts of the Directors for the half year ended 30th June last, to be submitted to the shareholders at the twenty-sixth ordinary general meeting, to be held on the 27th October, at Winchester House, 50, Old Broad-street, E.C., at 2 o'clock.

The gross receipts, inclusive of Government subsidies, have amounted during that period to £224,843. 0s. 1d., against £259,476. 9s. for the corresponding half year of 1885. The working and other expenses, including £31,361. 5s. 9d. for cost of repairs to cables and expenses of ships, absorb £81,775. 7s. 1d., against £74,418. 6s. 9d. for the corresponding half year of 1885, leaving a balance of £143.067. 13s. From this is deducted £3,992. 7s. 7d, for income-tax, and £41,595 for interest on debentures and contributions to sinking funds, leaving £97,480. 5s. 8d. as the net profit for the half year, against £140,358. 6s. 11d. for the corresponding period of 1885. One quarterly interim dividend of 1¼ per cent., amounting to £31, 250, has been paid during the half year, and another of like amount will be distributed on the 15th instant. In consequence of the diminution of revenue, which is attributable to the causes referred to at the last general meeting, and which unfortunately still prevail, your Directors do not feel justified in paying a bonus for the past half year, and have therefore decided to carry forward the balance of £34,980. 5s. 8d. to the next account. In accordance with the provisions of the trust deed, dated 10th May, 1879, 251 Five per Cent. Australian Government Subsidy Debentures were drawn on the the 12th April last, for payment at par on the 1st July. The numbers of the drawn debentures are given in the Directors' report. The renewal of the Penang-Singapore (original) cable, referred to in the last report, was successfully completed on the 5th June last, and a considerable portion of the old line has been recovered. The cost of the operation will be dealt with in the accounts for the current half year. There have been numerous repairs to the Company's cables during the past half year, but no serious interruptions occurred during that period. Unfortunately, since the close of the half year, both the Madras-Penang and Rangoon-Penang cables have been simultaneously broken, which totally interrupted the communication between India and this Company's system for 13 days, and resulted in considerable loss of traffic. Notwithstanding the prevalence of the South West monsoon, the Company's maintenance steamers have been successful in repairing both sections. All the Company's cables are now in good working order. The land line between Port Darwin and Adelaide, belonging to the South Australian Government, has, as usual, been well maintained during the half year under review.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. OCT. 20.		BUSINESS DONE WEEK ENDING OCT. 20. Highest.	Lowest.
Anglo-American	36½,	37½	37½	35
Do. Preferred	58½,	59½	59	55⅞
Do. Deferred	12⅞,	13½	13½	11⅝
Brazilian Submarine	10⅞,	11⅛	11⅛	10 15-16
Cuba	11⅛,	11⅜	11⅜	—
Do. Preference	18,	19	—	—
Direct Spanish	1⅛,	2	—	—
Do. Preference	8⅛,	9½	—	—
Direct United States Cable	9⅛,	9⅜	10⅜	10 11-16
Eastern Telegraph	10½,	10⅝	10⅝	10⅝
Do. 6 per Cent. Preference	14⅛,	14⅜	14⅛	14⅜
Do. 5 per Cent. Debentures, 1899	105,	108	106	—
Eastern Extension	10⅜,	11	11⅛	10⅜
German Union	9⅛,	9⅜	—	—
Globe Telegraph and Trust	5⅞,	6⅛	6⅛	5⅛
Do. Preference	12⅜,	13⅛	13⅛	12⅜
Great Northern	13⅛,	13⅜	13⅜	13⅜
Indo-European	35,	36	35	—
Reuter's	7⅛,	7⅜	7⅜	—
Submarine	195,	205	—	—
West India and Panama	⅝,	¾	—	—
Do. 1st Preference	8,	8½	8 7-16	—
Western Brazilian	6⅜,	6⅝	—	—
Western Union 7 per Cent. 1st Mortgage	118,	122	—	—
Do. 6 per Cent. Sterling Bonds	101,	103	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	13-16	15-16	—	—
Oriental	3-16	5-16	—	—
United Telephone	14⅜,	14⅝	14 11-16	14½

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	2⅛,	2⅜	—	—
Do. (fully paid)	4,	4½	4 1-16	—
Swan	1,	1¼	—	—
Maxim Weston	3-16	5-16	—	—

MISCELLANEOUS.

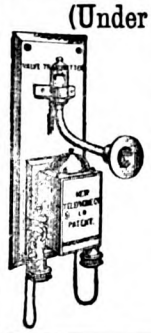
Telegraph Construction	39	40	39⅞	39½
India Rubber, Gutta Percha, and Telegraph Works	24	25	24¾	—

TRAFFIC RECEIPTS FOR SEPTEMBER, 1886.

COMPANIES.	Sept., 1886.	Sept., 1885.	Increase.	Decrease.
Cuba Submarine	2,250	2,160	90	—
Direct Spanish Telegraph	1,751	1,793	—	42
Eastern Extension	30,107	41,845	—	11,738
Eastern Telegraph	40,778	47,849	—	7,071
Great Northern	25,600	—	—	—
West Coast of America	3,585	—	—	—

NEW TELEPHONE CO., LIMITED

(Under License from the Postmaster-General).



The above Company is SELLING TELEPHONES to the Public outright. These Telephones are Manufactured under the Patents of Professor Silvanus P. Thompson and others, and are now in successful operation in leading towns in the kingdom.

The Company will give a formal guarantee to any purchaser requiring the same against any claims which may be made by trade rivals for alleged infringements.

This Company is now receiving applications for the establishment of local exchanges.

For full particulars apply to the Secretary,

NEW TELEPHONE COMPANY, LTD.

4, Great Winchester Street, London, E.C.

WILLIAM BANKS,

ELECTRICIAN,

CONTRACTOR for ELECTRIC LIGHTING and ALL KINDS of ELECTRICAL ENGINEERING,

32, CORPORATION STREET, BOLTON.

Telegrams "BANKS, BOLTON" Works, BARK STREET.

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NOTES.

TELEGRAPH CABLE REPAIRED.—The Post Office announces that telegraphic communication with the Scilly Islands is now restored.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 22nd inst. amounted to £3,616.

CABLE TO MADAGASCAR.—The Portuguese Government has authorised the French cable to Madagascar being landed at Mozambique, which will therefore be one of the stations of the new line.

MUIRHEAD'S NEW FORM OF STANDARDS OF E.M.F.—Dr. Muirhead informs us that his new standard cells can be obtained from Messrs. Muirhead and Co., Cowley-street, Westminster, S.W.

ENFIELD.—During the coming winter it is intended to run the Enfield Small Arms Factory all night, by aid of the electric light. The plant for this purpose was purchased some months ago, but it has not as yet been erected.

EASTERN TELEGRAPH COMPANY.—This company announce the payment by interest warrants on 1st November next, of interest for the half year ending 31st October, 1886, on their Four per Cent. Mortgage Debenture Stock.

SICILY.—The electric light is making some progress in Sicily. A distillery at Messina was lately supplied with an Edison plant, and the success of this installation appears to have stimulated quite an active inquiry in the district.

CONTINUOUS CURRENT TRANSFORMERS.—We have received from Messrs. Paris and Scott, of Norwich, a circular containing an account of their combined motor and dynamo for effecting the conversion of high tension into low tension currents.

STREET LIGHTING AT DOMFRONT.—The streets of Domfront are now illuminated by 52 Edison incandescent lamps of 16 candle-power. The dynamo is driven from a turbine on the River Varenne, at a distance of 1,500 metres from the village.

SHIP LIGHTING.—The "Prince of Wales," the latest addition to the London and North-Western Company's fleet, made her trial trip on the 26th inst. The vessel has been fitted throughout with electric light by Messrs. King, Brown and Co., of Leith.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended October 22nd were £2,975, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

THE CROMPTON POCKET-BOOK.—We have received from Messrs. Crompton and Co. a copy of their "Price List and Useful Formulæ," which contains a large amount of valuable information for the practical electrician in a concise and readily available form.

RAPID PASSAGE OF THE SUEZ CANAL.—The ss. "Salazie," belonging to the Messageries Maritimes Company, by the aid of her electric lights, has just made the passage of the Suez Canal in sixteen hours, this being the shortest time on record. She passed twenty-two stationary vessels *en route*.

THE ACCIDENT AT THE PARIS GRAND HOTEL.—This accident, to which we referred last week on the basis of a somewhat incoherent account from the correspondent of a daily journal, turns out to have been a boiler explosion, and therefore has no real connection with the electric light.

THE DIRECT SPANISH.—The case of Bannatyne *v.* The Direct Spanish Telegraph Company, concerning the question which has recently been put before the company for a reduction of capital, as reported in our issues of October 1 and 22, is to be heard to-day (Friday), before Vice-Chancellor Bacon.

ITALY.—A project has been set on foot in the columns of our Milanese contemporary, *L'Elettricità*, for the establishment of an Italian Society of Electricians. It is contemplated also to provide a library, a technical school, and a public laboratory. We hope that the scheme will meet with the success which it deserves.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY.—This company notify that the coupon on their Five per Cent. Manilla Debentures (1880 issue), due on November 1st proximo, will be payable on and after that date on presentation at the Consolidated Bank, Threadneedle-street, E.C.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—At a meeting of the directors of this company, held on Wednesday last, it was decided to place £7,000 to reserve, and to recommend a dividend of 8s. per share on account of arrears of dividend on the First Preference shares to the shareholders at the approaching meeting.

PERSONAL.—Mr. H. Kingsford, late electrician on board the steamship "Mackay-Bennett," and who a short time since accepted the position of engineer and electrician of the Central and South American Cable Company's system, has been very successful in repairing two of that company's cables, one repair having been effected in thirty-six hours.

HONOURS TO AN ELECTRICIAN.—The Senate of the Royal University of Ireland has bestowed their highest scientific degree of Doctor of Science upon Prof. John Perry, F.R.S. Prof. Perry is an old graduate of the Dublin University, and this recognition of his undoubted claims to high scientific distinction is as creditable to the magnates of the Senate House as it must be gratifying to the Professor himself.

TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY. This company notify that the twenty-third distribution on the certificates issued under the trust deed of March 12, 1875, will be made on and after November 1, 1886. The distribution which arises from dividends on the shares held by the trustees will be at the rate of 9d. per £5 certificate, payable two clear days after presentation of Coupon No. 23 at Messrs. Barclay, Bevan, and Co.'s bank.

CABLE JOINTS.—In view of the importance of ensuring thoroughly good joints in electric light cables, Messrs. Walter T. Glover and Co., of Salford, have arranged to supply cables of various sizes jointed together before they are insulated, and in this way securing perfect joints, having equal quality of insulation with the rest of the cable, without bulkiness or possibility of leakage. Thus a cable is made of, say, $\frac{19}{10}$ths, $\frac{19}{14}$ths, $\frac{19}{18}$ths, all jointed in the core before being insulated.

FATAL ACCIDENT TO AN ELECTRICIAN.—The *Globe* states that a sad accident occurred on Saturday evening on the River Dart. While a party of London electricians were on board a steamer off Sharpham Point some of the men are stated to have commenced "skylarking." Alfred Tite, of Westminster, fell off the bow of the steamer, struck his head against the paddle wheels, and was drowned. The body was recovered. Tite leaves a widow and seven children.

NEW FRENCH ELECTRICAL COMPANY.—A new company, under what must surely be an old name resuscitated—La Compagnie Electrique—has just been floated in Paris, with a nominal capital of £60,000. The *Bulletin Internationale de l'Electricité* learns from a reliable source that the company will occupy itself chiefly with installations for the transmission of

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power. It is even said that they will be prepared to place upon the market plant capable of realising results superior to those of M. Marcel Deprez.

THE GERMAN TELEGRAPHS.—It is stated that the German Telegraph Administration are making a trial of an autograph recording instrument, by which the handwriting or drawings may be transmitted in fac simile. We do not know whether any really new principle is involved in this apparatus, but if it follows the lines of any one of the ingenious instruments which have already been devised for autographic transmission, it will probably fail in practice, as these have always done hitherto, from want of sufficient rapidity of action.

EAGLES.—According to the *New York Herald*, an incident which recently occurred at New-Haven, Connecticut, tends to throw grave doubt upon the ancient belief that an eagle can look at the sun without winking. It seems that a very fine specimen of this noble bird was recently captured alive in the streets of New Haven, having damaged himself by a collision with an electric light tower. This certainly tends to show that the bird was dazzled by the light; but possibly he suffered from myopia, or will the citizens claim that the incident merely proves that their tower lights exceed the sun in brilliancy?

FINSBURY TECHNICAL COLLEGE.—The last of the course of free popular Saturday evening lectures at Finsbury Technical College, Leonard-street, City-road, was given by Prof. Silvanus P. Thompson, D.Sc., on "Magnets and Electro-magnets." The chair was taken by the Lord Mayor, who was supported by Sir P. Magnus, Alderman S. Knill, Mr. E.C. Robins, Mr. Beck, M.A., Mr. J. Bigwood, Mr. Jennings (Master of the Drapers' Company), and others. The lecture was naturally of a non-technical character, and was illustrated with numerous experiments, which were followed with great interest by the audience.

CHINESE TELEGRAPH LINES.—The *Globe* recently contained the following paragraph:—"The Chinese Government have contracted with Messrs. Telge and Co. for the construction of a telegraph line from Tai-nan to Tai-pei. Messrs. Jardine, Matheson and Co. have obtained a contract for laying a cable from Amoy to Hoo-mee (Formosa), the cost of which is estimated at $210,000. It is expected that both of these lines will be completed before the end of this year." We have reason to believe that these contracts have received the sanction of the Governor of Formosa, but have yet to be confirmed by the Imperial authorities at Pekin.

INDIA.—The *Indian Engineer* of October 2nd commences a series of articles under the title of "Electric Light for India." The first paper is very well written and aims at enforcing the special advantages of the electric light in tropical climates, and endeavours to disabuse the Anglo-Indian mind of the prevalent idea that electric lighting has still to emerge from the experimental stage. The various details of an installation are then briefly described, the apparatus of Messrs. Siemens Brothers being more particularly referred to. We hope that this series of articles will answer their intended purpose, and give a decided impetus to electric lighting in our Indian Empire.

"HEAT INDICATING PAINT."—*L'Ingenieur Electricien* is perfectly correct in stating that it is no new discovery that the salt consisting of the double iodide of mercury and copper changes colour upon heating, and our contemporary may or may not be right in assuming that a "heat-indicating" paint recently brought out by Mr. Henry Crookes, of Westminster, is composed of this particular substance; but the journal in question is certainly wrong (and this is why we refer to the matter) in confounding the inventor of this paint with Mr. William Crookes, F.R.S, the discoverer of "radiant matter," of the metal thallium, and the indefatigable worker at chemical "fractionations."

COCOA PALMS AS LIGHTNING CONDUCTORS.—In a recent article the *Ceylon Observer* refers to the power of the cocoa nut palm to conduct lightning. Sir Emerson Tennent long ago pointed out that this tree acts as a conductor in protecting houses from lightning, and in one instance 500 palms were struck in a single plantation during a succession of thunder storms, in April, 1859. But the trees themselves suffer terribly in the process, for however slightly they may be touched by the electric fluid, they die. Sometimes only the edges of the branches are singed, at others a few leaves turned brown alone show where the tree was touched; yet, however slightly the apparent effect, in course of time the tree withers gradually and dies.

THE "VOLTA."—On Saturday last at the instance of Major-General Fred. Brine, a further trial of the capabilities of the electric launch, the "Volta," was made on the lower reaches of the Thames, in the presence of General Lord Chelmsford and other officers of both branches of the service. Those present included General Pritchard, General Sir R. Pollock, General Sir H. de Bathe, Admiral Sir Erasmus Ommaney, Admiral Curme, Captain Palliser, and Captain Murphy. The trip was from Westminster Bridge to Greenwich Hospital, where the party were entertained by Admiral Brandeth. A start was made at sixteen minutes to two, and the hospital was reached within eight minutes of the hour, a speed averaging something over six miles and a half per hour.

THE PARIS EXHIBITION OF 1889.—The *Journal Officiel* contains the following list of names of those who will form the committee of electro-technics for the International Exhibition of 1889:—MM. Ed. Becquerel, Alf. Cornu, Marcel Deprez, Maurice Lévy, Lippmann, Maurice Lœwy, Mascart, le Colonel Perrier, membres de l'Institut; Armengaud, membre du Conseil Municipal de Paris; Baille, Bartet, Bergon, Blavier, Caël, Carpentier, Chatard, Fontaine, Fribourg, Hospitalier, Huet, Joubert, Jousselin, Lemonnier, Ménier, Mercadier, de Méritens, Napoli, Gaston Planté, Postal-Viney, Potier, Raynaud, Richard, Ed. de Rothschild, Sartiaux, Sciama, le Colonel Sebert, Violle, Vivarez. The appointment of secretary to the committee has not yet been made.

A BIG MOTOR.—For some time past the technical press has contained more or less authentic paragraphs as to the construction at the Rhode Island Locomotive Works of an electric motor intended to develop no less than 670 horse-power. As these statements have recently become more circumstantial we give them for what they may be worth. The machine, which is said to be now actually completed, has been built from the designs of Messrs. E. M. Bentley and W. G. Knight. It is intended for use upon the proposed underground railway at New York. The engine runs upon six wheels of 68in. diameter, and is provided with electric head-lights, bells, and vacuum breaks, worked automatically by electricity. Every carriage in the train will also be fitted with an electric brake, and will be lighted throughout by incandescent lamps.

EQUIVALENCE OF CHEMICAL ENERGY AND CURRENT ENERGY.—H. Jahn, in the *Ann. Phys. Chem.*, gives an account of some experiments in which he proves Helmholtz's relation between the secondary heat of a galvanic element and its temperature coefficient. The elements examined were silver in silver nitrate, with lead in lead nitrate, and copper in copper nitrate respectively. The solutions had a strength of $(M')_2(NO_3)_2 + 100H_2O$. The chemical heat of the cell is obtained from the formula $Q = W - aJ(\Delta Jg)t$, where W is the

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heat evolved in cell, a the heat equivalent of unit of work, J the current intensity in amperes, $\Delta - Jg$ the potential difference of poles, and t the duration of the experiment. The values obtained from this formula agree closely with those obtained from thermo-chemical data. The chemical heat less the current heat gives the secondary heat, which is compared with that obtained by calculation from Helmholtz's relation. The following are the results :—

Element.		E. M.F.	Chemical heat.	Current heat.	Secondary heat.	
					found.	calc.
$Ag_2, Ag_2(NO_3)_2$	$Pb(NO_3)_2, Pb$	0·932	50·87	42·98	7·95	7·89
$Ag_2, Ag_2(NO_3)_2$	$Cu(NO_3)_2, Cu$	0·458	30·04	21·12	8·92	8·92

ENGINE TRIAL.—One of the most satisfactory engine trials ever carried out took place on Wednesday last at the Colonial and Indian Exhibition. Messrs. Davey, Paxman and Co. placed at the disposal of Mr. W. E. Rich, C.E. (late partner with Messrs. Easton and Anderson, of Erith, Kent, who have carried out so successfully the trials of engines for the Royal Agricultural Society of England), and Prof. A. B. W. Kennedy, University College, Gower-street, W.C., for carrying out a perfectly fair and impartial trial of one of their engines and boilers at the above Exhibition in order that it might be known to consumers what duty would be performed, and the amount of coal and water used by an engine and boiler after having been in work for three years. The engine in question is of the semi-fixed compound type, having cylinders 12¼in. and 20in. diameter respectively, by 24in. stroke. The result of 5 hours and 42 minutes' trial was exceptionally good, and Messrs. Davey, Paxman and Co. are to be congratulated upon the figures which were obtained. As the trial took place too late to allow us to have illustrations made for this week's issue, we refrain from discussing the figures, but have merely given the event as a matter of history.

A NEW COULOMB-METER.—M. Jacquemier has devised a coulomb-meter based upon the following principles :—An ampere-meter, which may be of any known construction so long as the deflections are proportionate throughout the scale, is connected with a train of clock-work. A wheel which makes one turn per minute carries a detent. At every revolution the latter closes with a second train of wheels, by means of which the index is moved upon the scale where the coulombs are read. The moment when the two trains gear together is that at which the detent upon the first wheel is passing zero point upon the scale of the ampere-meter; the disengagement, upon the other hand, is effected when the detent arrives at the needle of the ampere-meter, wherever it may be upon the scale. Thus the distance traversed by the needle of the coulomb-meter at every revolution—that is, once every minute—is proportionate to the current indicated by the needle of the ampere-meter. If the ampere-meter is not constructed to give proportionate deviations, M. Jacquemier employs a suitable can, mounted upon the same axle, to carry the detent. From this description it will be seen that the method is not accurate when the current strength undergoes any rapid fluctuations.

A BARBER'S VIEWS ON ELECTRIC LIGHTING.—A New York barber has recently expressed the opinion that when the electric light becomes universal, baldness will be comparatively unknown. Middle aged gentlemen who find their hair getting "thin at the top," will do well to ponder the observations of this authority. He says :—"You will notice that there are no classes of men more frequently bald than retail salesmen, bookkeepers, and office clerks in certain lines of business. Why should baldness affect them more than others? Because they habitually stand or sit nearly every evening under gas-lights. The artificial heat dries out the hair, makes it brittle and unhealthy, and finally kills it at the root. If you will pass your hand through your hair after you have been standing under a gas-light for a few moments you will see at once how it is. Although you may not have noticed the heat on your head, your hair, if you've got any, will be hot to the roots. You'll be surprised to observe, too, at what a distance from the light the hair will absorb the heat, and there is nothing so bad for the hair as getting it dry. I have an idea, too, that after the electric light has been in universal use for a generation or two, baldness will be as scarce as it was before gas-lights and nightwork got common together."

AMERICAN VIEWS ON ENGLISH ELECTRICIANS.—We quoted last week a somewhat unflattering opinion upon the electricians of this country which had been expressed by an American professor. We have therefore additional pleasure in quoting the following paragraph from a New York contemporary journal :—"There are many signs that the revival of electric lighting in England has begun, in spite of the tremendous obstacles that are placed in the way of those who desire to engage in the business. The fact that the industry is as a whole in good shape to-day bears no small testimony to the bulldog tenacity and genuine 'grit' of our British cousins. The men who have held on through the days of trial deserve our sympathy and praise, and it is only to be hoped that new and reasonable legislation will soon be given them as aid and stimulus in the arduous work still before them. The fact is, English electricians and companies have done their best in the only fields that remained open to them, that of isolated arc and incandescent lighting in works or residences, and that of special lighting on ship board. If now the unfair legislation against electric light enterprises of the larger kind is removed, or even if the English gas companies undergo conversion, as the American gas companies are doing, we shall see central stations in every part of the country."

GALVANIC POLARISATION.—From the abstracts of papers in the *Journal* of the Chemical Society we take the following :—Determinations have recently been made by Herr H. Jahn of the electromotive force of polarisation of solutions of various salts. The apparatus used consisted of a tuning-fork contact breaker, by which the solutions were alternately polarised by a battery of three Bunsens, and circuited through a tangent galvanometer, the latter being compared with a Clark's cell. The polarisation cell was placed in melting ice. The values obtained were compared with the E.M.F's produced by elements formed of different pairs of the salts experimented with, thus : $p_{ZnSO_4} - p_{CuSO_4} = E$; the results compared very favourably. From these values, the secondary heat evolution, as distinct from that due to resistance, is determined from the equation $W_s = aJpt - Q$, where W_s = secondary heat, a = heat equivalent of unit of work, J = strength of current, p = polarisation E.M.F., and Q = heat of combination. The results agree closely with those obtained by Favre by direct experiment. It is remarkable that they are all multiples of the same number; thus copper, zinc, and cadmium salts = 2 × 10 cal.; lead salts = 3 × 10 cal.; silver salts and sulphuric acid = 4 × 10 cal. Lastly, the polarisation E.M.F.'s of the same salts for a temperature of 34° were determined. For zinc or copper salts, the polarisation E.M.F.'s are in much the same relation as at 0°, hence the E.M.F. of a Daniell element must, in accordance with Helmholtz's laws, be independent of temperature.—*Ann. Phys. Chem.*

ELECTRIC LIGHT AT ANVERS.—At Anvers, Belgium, there are several large factory buildings which are let out in separate shops to the working lapidaries, who form such an extensive colony in this district. Both light and motive power are

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usually included in the rent of the shops, but as a rule the lapidaries very seldom work by artificial light, even in the shortest days of winter, as the men have a strong (and reasonable) prejudice to working in an atmosphere heated and contaminated by gas. This statement represents a fact which can readily be verified by inquiry on the spot. A notable opportunity is here afforded for the introduction of electric light. The first extensive installation of this character in Anvers has just been completed, and we have received a very detailed account of the arrangements, which will probably be of interest to many of our readers. This installation, which has been put in on behalf of M. Leytens, consists of 100 Victoria incandescent lamps of 16 candles; the dynamo is of the Gulcher type, but has undergone modification at the hands of M. Dufait, engineer, at Charleroi. The machine gives 125 amperes at 70 volts, and runs at 500 turns a minute. Hedges' fusible cut-outs are provided upon one of the mains, and a magnetic cut-out constructed by M. Dratz upon the other. A "De Hummel" voltmeter is connected with the terminals of the machine. All the conductors are placed in wooden grooves, which are provided with covers. The lamps are suspended from the ceilings, and provided with shades and reflectors to concentrate the light upon the working benches. The workmen themselves express entire satisfaction with the light, and in other factories they are already agitating for its introduction.

THE BRUSSELS EXHIBITION OF TELEPHONY.—We have already informed our readers that in the early weeks of 1887 it is intended to hold in Brussels an International Exhibition of Telephony upon an extensive scale. The arrangements in connection with the undertaking are being carried out by the Société Belge des Ingenieurs et des Industries, with whom the Belgian Society of Electricians has recently been amalgamated. We have received from the secretary of the society a letter requesting us to make known the objects of the Exhibition, which are set forth in an enclosed circular as follows:—"This Exhibition is intended to display all the apparatus and processes hitherto devised for the transmission of the human voice to a distance, and the application of these methods down to the latest date. Its character will be both scientific and practical. The exhibits will therefore comprise telephones, microphones, radiophones, and phonographs; switch-boards and other appliances connected with telephone exchanges; 'toll' stations; conductors and insulators, and all 'outdoor' appliances. Further, special consideration will be given to anti-inductive systems, to the use of cables containing large numbers of lines, to long-distance telephony and apparatus connected therewith, and to systems of simultaneous telegraphy and telephony. In addition to actual apparatus, plans, diagrams, or models will be received. A series of experiments and of competitive trials will be undertaken and conferences will be held. No charge will be made for space. Applications must be sent in before 1st December. The Exhibition will remain open for five weeks. Any one desiring to contribute to the discussions, or to make any suggestion with regard to the experimental work, is requested to communicate with M. H. Aerts, the president of the committee of conferences and exhibits."

THE ELECTRIC LIGHT IN MADRID.—The Madrid paper *El Dia* of the 24th inst. states that a meeting of the Madrid Mercantile Club was to be held on Monday last to consider the proposal for the installation of the electric light which was drawn up by the committee appointed for that purpose. The proposal in question limits the installation of the new light to an area embracing the most important thoroughfares of the city—viz., the whole of the Puerta del Sol, part of the Carrera de San Jeronimo, and the following streets: Carretas, Montera, Arenal Postas, and portions of Alealá, Cármen, Preciados, and Calle Mayor. It is estimated that in order to light the establishments in the district named, 16,300 sixteen candle-power lamps will be required. The cost of the installation is estimated at 500,000 pesetas, say £20,000, that sum to include machinery and electrical appliances. It is calculated that the annual cost of the light, including material, staff, offices, taxes, depreciation, &c., will amount to 170,827 pesetas, say £6,835. Subject to the due ratification of the project, it is proposed to incorporate an electric light company, with a capital of 500,000 pesetas, divided into 2,000 shares of 250 pesetas (£10) each. The committee estimate that the saving to those who use the light will be at the outset forty per cent. and considerably more after a few years. The cost of gas is placed at slightly over 5 centimes per burner per hour, while the cost of the proposed electric light will not be more than 3 centimes, and probably as low as two centimes after the first five years. As an illustration, it is affirmed that the cost of gas in an establishment with 12 lights burning five hours per day is 92 pesetas 60 centimes (say £3. 14s. 9d.) a month, whereas an equal number of electric lamps, burning the same length of time, will only cost 54 pesetas (say £2. 3s. 4d.), and will at the same time yield a better light.

THE LATEST ACCUMULATOR.—The "invention" of secondary batteries proceeds merrily. The very latest type of which we have been able to obtain information up to the hour of going to press is due to the labours of M. Montaud. The preparation of the plates is thus described:—"The electrodes are placed in a bath containing a saturated solution of an alkali, and which also contains an excess of litharge. The current being passed through the bath, one of the plates is peroxidised and the other becomes coated with spongy lead. The latter plate is afterwards submitted to strong mechanical pressure. The chemical action in the baths is very rapid." M. Montaud employs very thin plates having a large superficial area. The principal advantages which are claimed for this battery, and which we shall be very glad to find substantiated in practice, are the following:—(1) Rapidity of charge; (2) high efficiency; (3) output large in comparison with total weight. The authority from which we quote makes a fourth claim on behalf of the cells, to the effect that the battery is of small weight in comparison with its total output. It may be that our logical faculty is small in comparison with the considerable output of mental effort which we have made to understand exactly what is here meant; but up to the present we have been unable to determine the precise distinction between claim (3) and claim (4). The capacity is given in terms of the "square metre of useful surface" as 50 ampere hours, and in terms of weight as 9·1 ampere hours per kilogramme of "useful" lead. The normal charging current per kilogramme of "useful" lead is two amperes, but this may be doubled without injury. The normal current of discharge in the same units is 4·5 amperes, and this quantity may be increased without inconvenience to 20 or 25 amperes. We can only again express our desire to find these figures realised in practice.

H.M.S. "LAWRENCE."—On Saturday last the official trial of the electric lighting installation on board H.M.S. "Lawrence," took place at Gilbrook Yard, Birkenhead. The "Lawrence" is a despatch boat, built by the firm of Messrs. Laird Brothers, of Birkenhead, for the Indian Government, and is luxuriously fitted up for the use of the Vicroy and suite. The installation consists of two Goolden-Trotter A dynamos, giving 8,800 watts each at 400 revolutions, coupled direct to a pair of Willans three-cylinder compound tandem engines.

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There are 125 Edison-Swan 20 candle-power lamps at 80 volts, which are placed in "Trotter dioptric shades" throughout the ship. The fittings are of the Admiralty pattern, except in the saloon and chief cabin, where they are of a more ornamental character, and are electro-plated. A yard-arm reflector is also provided, and fitted with eight 50 candle-power lamps for use when the vessel is coaling. The dynamos are placed in a room on deck, an arrangement which will allow of ample ventilation, presenting a favourable contrast in this respect to the usual position of dynamos on board ship. The entire work of the installation was carried out without dockyard assistance by the firm of Goolden and Trotter within five weeks from the commencement. At the trials on Saturday Mr. Jopp, the Director of Stores, was present on behalf of the India Office, Mr. Hudson being the inspecting officer in the unavoidable absence of Sir Edward J. Reed, M.P., K.C.B. Mr. John Laird and Mr. Henry Laird were also present. The dynamos ran extremely well, were perfectly cool, and quite sparkless at the commutators at some fifty revolutions under the contract speed. The lamps also were the subject of some remark, for, while giving a light of fully 20 candles at 80 volts, when the speed was reduced and the voltmeter indicated 50 volts, the light appeared to be nearly 15 candles, and the ship was still well lighted. At the close of the inspection Mr. Jopp tendered his thanks to the contractors, and Mr. R. A. Scott, their superintendent, and expressed his gratification at the manner in which the work had been done. Some of those present ventured to express the opinion that the "Lawrence" was better lighted than any other ship at present in Her Majesty's service. Messrs. Goolden and Trotter have also finished the installation of the troopship "Dalhousie," and we understand that the official trial takes place this week.

THE EFFICIENCY OF ARC LIGHTING.—Mr. John Wallace, C.E., contributes to the *Indian Engineer* an able paper upon "Petroleum," in the course of which he makes a comparative estimate of the amount of light obtainable by different methods from the incandescence of carbon. He refers to the arc light as follows:—The incandescence of carbon in the electric lamp is worth referring to, just to show what are the possibilities of lighting by means of highly-heated carbon particles. For the purposes of comparison, we shall refer only to the carbon used in an arc lamp, and to the power, reduced to heat units, required to produce the electric current, which renders it incandescent. And in the same manner we shall treat the carbon used in gas lighting, and the heat, in units, employed to render it incandescent. The steam power used to produce through a dynamo one-candle light for one hour in an arc lamp is equal to 907·2 foot pounds, or 1·17 unit. The carbon burnt in the atmosphere is equal to ·151 grain in weight, and converts to ·28 unit, making a total of 1·45 or nearly 1½ heat units. This is exactly the quantity of heat required to raise 1½ pounds of water 1° F. in temperature, and may be taken as the equivalent of one electric candle-light for one hour. The force required to produce one candle-light from coal gas, is that produced by the combustion of 62·5 grains of gas containing 45 grains of carbon and equal to 188 units. The ratio of the two totals of units is as 1 to 129, and the ratio of the consumption of carbon is 1 to 160, so it is evident that if the gas carbon could be burnt with the same economy as that in the arc lamp it would burn with a light of 160 candles instead of only one. Is this possible? Dividing the totals of units, in each case, by their respective weights of carbon, we find that each grain of carbon in the arc is acted on by a force equal to 9·6 units of heat, while each grain of carbon in the gas has only 4·17 units to heat it. In incandescent economy, therefore, gas can never compete with electricity, but, seeing the amount of waste that takes place in the gas burner, there must still be room for much improvement. The combustion of carbon in the arc lamp is effected at a much higher temperature than in the Argand gas burner, and this fact seems to be fully recognised in the Wenham burner, which uses the heat of its waste products to superheat the gas and air going to the flame. By this means the discrepancy between gas and electric lighting has been reduced from $\frac{1}{160}$ to $\frac{1}{100}$. The limit to the further improvement of the Wenham burner, and others of its class, will probably be determined by the heat resisting power of the material used in their construction.

THE JARMAN ELECTRICAL TRAM CAR.—On Monday last Mr. Jarman, of Brixton-road, exhibited a working model of a tramcar driven by primary batteries. The model, which was some 2ft. in length and with the batteries weighed nearly 1½cwt., was shown running very smoothly upon a circular line, which contained several curves of 6ft. radius. Mr. Jarman makes no claim for any improvements or for any special construction of either batteries, motor, or gearing. The primary batteries were only employed as a matter of convenience, any other method of furnishing the required current is equally within the province of this system. The motors may equally be of any known type, those shown were of Mr. Jarman's own construction, but being mere models, it is of course useless to criticise them. The gearing adopted consisted of an ordinary train of spur and mitre wheels having no special feature, but it is proposed to employ hornbeam teeth when working on a larger scale. By this time our readers are possibly at a loss to imagine what can be the points which are to be considered distinctive features in Mr. Jarman's electric tramcar. Not to keep them longer in suspense, we proceed at once, and in few words, to unfold the secret. Two distinct motors of identical construction are mounted side by side, with their armature shafts coupled in one line, and driving each on to the same toothed gearing, the arrangement being in this respect very similar to that adopted by Mr. Reckenzaun for his electrical boats. Mr. Jarman's object is, however, somewhat different. The brushes are connected to a reversing lever placed under the control of the driver, and it is arranged that when one pair of brushes is on the commutator the other is lifted, so that only one motor is in circuit at a time. It is further arranged that one motor drives the car in one direction, and the other in the opposite direction, so that, in the words of the inventor, "each armature has its time to cool down should it become heated." By this means Mr. Jarman overcomes the difficulties which may arise from the overheating of the machine, owing to too prolonged working. Our readers will form their own opinion as to the value of this device, but we may ask them to remember the fact that a tramcar is liable to very numerous stoppages. Whenever a fresh start is made the coils of the motor are necessarily subject for a short time to a current far greater than they can safely bear for any length of time, and this certainly tends to render the question of heating of even greater importance than ordinarily in the case of motors employed for this special purpose. At the same time it must be admitted that if we resort to a device of this character, we practically confess ourselves baffled in the search for a thoroughly satisfactory solution of this particular phase of the problem of the electrical transmission of energy; and our columns have of late borne testimony to the fact that there are still electricians, both in this country and abroad, who would not care as yet to confess themselves beaten in this matter.

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THE IMMISCH ELECTROMOTOR.

(Continued from page 490.)

There still remain some points of interest to be noted in connection with the Immisch motor of 1885. If our readers will turn back to the diagram of the armature winding, Fig. 4, page 489, they will notice that the polarity of the Pacinotti teeth has in every case been indicated twice over. We will presently explain the reason for this. By increasing the size of the lettering in the diagram, as we travel away from the neutral points (*o*), an attempt has been made to indicate the relative strengths of the successive poles of the armature field. The lettering does not show the actual or resultant polarity of the teeth when the machine is in action, but it indicates the poles which tend to be formed by the current in the coils of the armature. The letters upon the teeth themselves indicate the poles for that position of the commutator which is shown in the figure, that is when coil A has just been cut out. The outside letters indicate the position of the poles in space when the armature has advanced through an angular distance of about 28°—that is, just under one-twelfth of a revolution. In this position coil A is about to enter the circuit, and coil B is upon the point of being cut out.

It follows from this that the position of the armature field in space is continually shifting to and fro over a space equal to rather less than one-twelfth of a revolution. It is true that the influence of the field-magnets tends, to a certain extent, to steady the *resultant* field, nevertheless fluctuations of this character cannot but have an injurious tendency. We have now completed our catalogue of the defects of the machine which carried off the silver medal last year, and we shall presently endeavour to enable our readers to judge for themselves how far they have been remedied in the type which has been finally adopted.

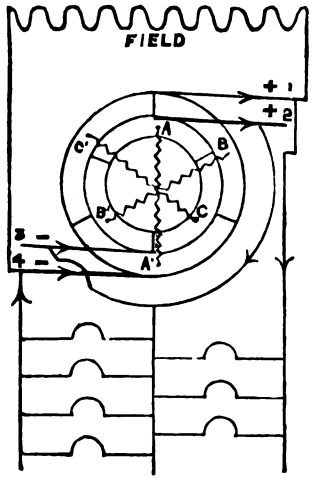

FIG. 5.—Dynamo working on Three-Wire System.

Before, however, we take leave of the results which were obtained in the year 1885, it must be mentioned that meanwhile Messrs. Immisch had been giving attention to the question of dynamo construction as well as that of motors, and had discovered a field for the application both of their bi-sected commutator, and also for the principle of cutting out of circuit that particular coil which tends most to distort the magnetic field; the result being that in the same year, 1885, they constructed a remarkable machine, which, although somewhat resembling the Brush and the Thomson-Houston types in the matter of commutation, has yet, we believe, a perfectly unique claim to distinction, inasmuch as its armature is capable of being run simultaneously upon both circuits of the Edison-Hopkinson three-wire system of distribution. This machine was at work for some five or six months at the Inventions Exhibition, and ran well and without sparking or other difficulty, and this whether the resistances of the two external circuits were or were not in balance.

After what has already been said the construction of the machine will be easily understood from the diagrammatic view in Fig. 5, which shows the connections of the entire circuit. The armature consisted of three coils only, of which one is always cut out by open circuiting—in the figure *c c'* is in this position. The commutator consists of two rings or sections, each with three segments, as already described.

The coils are joined across from a segment of one section to a segment upon the other section, and the two segments are so displaced with regard to one another that their centre lines are 180° distant. By altering the external coupling of the brushes the two coils might be run either in parallel or in series, but for use with the three-wire system the connection is necessarily in series. To join in parallel the + brushes 1 and 2 and the − brushes 3 and 4 would be connected together. To join in series 1 and 4 are left open, and become the terminals of the external pair of mains, and 2 and 3 are connected together, and are then joined in common to the third wire of the network. While we have thus two independent external circuits, the total work is equally distributed among the three coils. The field is shunt-wound, and can either be excited from the whole of the armature or at half the potential from either section. It is, however, clear that, except perhaps upon a very small scale, there are economical objections to the principle of cutting out one-third of the armature wire twice during each revolution (each time over an angular distance of 60°), and before the principle could receive any extensive application it would be necessary considerably to increase the number of coils upon the armature. Theoretically, it is possible to adapt this method to any winding in which the number of coils remains some multiple of three, only it would be necessary at the same time to increase the number of commutator rings. This implies an increase in the number of brushes and very complex connections, so that even with six coils the construction becomes difficult, and beyond that number would probably be found to be impracticable. It is, however, evident, from the performance of the dynamo shown at the Exhibition last year, that if any use can be found for small three-coil machines of this type, the construction is available.

Sufficient has now been said to show that while a substantial advantage is gained from the introduction of the principle of cutting a certain portion of the armature out of action at a certain angular position, yet when this is done by open circuiting a rather heavy price is paid for the privilege. But Messrs. Immisch now claim that in the latest type of their machines, both motors and dynamos, they have succeeded in retaining all the advantages while completely overcoming the objections to the principle, and at the same time both the output and the efficiency of the machines have reached a high figure.

The means by which these results have been attained are sufficiently simple—in conception at least. As already hinted, the coil is now cut out by short-circuiting instead of by open circuiting. The limits of our space will not permit us to enter at great length into a discussion of the reasons why this comparatively simple modification entails such beneficial results. To some extent it is a matter of constructive practicability. For instance, it is no longer necessary, as it was in the previous case, for the motor winding to be of such a character that at the same moment two coils at right angles are cut out of action—only one being actually necessary. An obvious gain results, both as to efficiency and as to output. Secondly, there is no longer such difficulty in increasing the number of coils, thus again reducing the proportionate quantity of wire placed out of action. Thirdly, owing to the re-arrangement of the armature field the brushes are now placed at right angles to the line joining the field poles, and the machine can thus be run in either direction by a simple reversal of the connections of either field or armature. This latter very important feature the Immisch motor shares, however, in common with the Reckenzaun, and some other less known types. Fourthly, and as a consequence of what has gone before, there is no longer any limit to the application of the principle to machines of any required dimensions, whether dynamos or motors. Dynamos of this description have already been constructed with outputs varying between 500 and 10,000 watts. The two 20,000 watt machines for charging accumulators in parallel, and to which we have already referred as being now under

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construction, are also of this type. Motors giving a brake horse-power of ½ to 12 have been built with entire success. A large machine of this type is now almost complete; it is designed for an output of 40 horse-power, and with an anticipated efficiency of 94 per cent.

We have already given a perspective view of a six horse-power machine in Fig. 1, p. 488. The winding of the armature is diagrammatically shown in Fig. 6; for the sake of clearness only 8 coils are indicated, whereas 48, 96, or even 144 coils are employed in practice. The commutator is of the bisected type already described, and, as will be seen from the figure, the coils are joined to two adjacent segments of the commutator on the two rings, of which one has an angular advance equal to one-half the width of the commutator bar. The two brushes side by side upon the two rings are connected together, so that only one pair is shown in the figure. Tracing the connections in the figure, if we start from one ring of the commutator under the brush, say with the coil marked 1, we cross to the other side of the armature, and thence join the connection leading to coil 6; but if we follow this line backwards to the commutator we arrive at a segment under the same brush from which we started. Similarly coil 5 connects with coil 2, and is

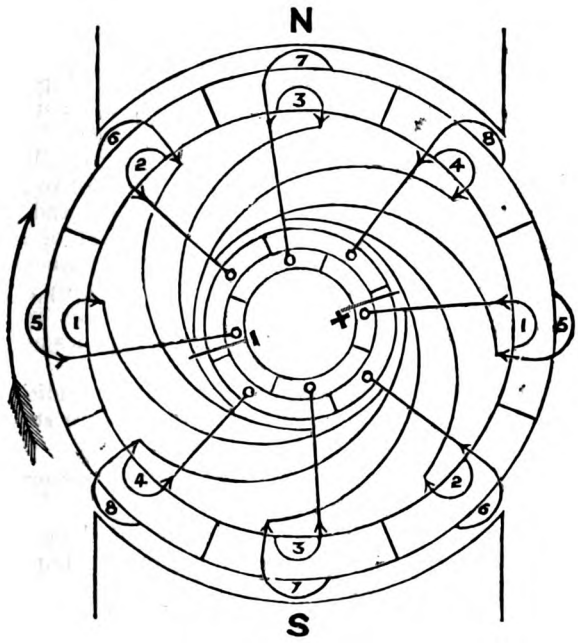

Fig. 6.

short-circuited in the same way by the other brush. It will be observed that the magnetic axis of the armature itself would be situated underneath the coils which are short-circuited. The remaining connections require little comment, the two halves of the circuit can be traced through coils 6, 3, and 4 in series upon the one side, and coils 8, 7, 2 in series upon the other.

It is, however, apparent that, after all, this is only tantamount to the use of an armature of normal type, together with a brush, having a very wide face, so that its period of contact with two adjacent segments of the commutator is abnormally prolonged. It was therefore fully anticipated when the first experiments were made that much trouble might arise from the heating of the coils during the period of short-circuiting, which occurs twice in every revolution. In practice, however, no such effect was ever found to occur so long as the field poles were properly proportioned, and in the case of a motor the brushes may even be shifted some distance to either side of their normal position without producing either sparking or any perceptible increase of heating. But, somewhat singularly, this remark does not apply in the case of a dynamo of similar construction, and the position of the brushes has to be adjusted with some care. So long as this is attended to the machine runs with perfect smoothness; but directly the brushes are displaced, although little or no sparking takes place, yet a considerable and rapid heating of the coils ensues. This feature has, however, little practical importance, for when the position of the brushes has once been determined they can be rigidly fixed, and the dynamo requires no further adjustment whether running on open circuit or with full load. It is hardly necessary to say that the non-heating of the coil proves that during this part of the revolution the algebraical sum of the number of lines of force passing through it is constant. Hence Mr. Albion T. Snell (the electrician to the Immisch Company) explains the discrepancy between the action of dynamos and motors in this respect upon the supposition that the angular distance upon the armature core over which no lines of force either enter or leave the iron is greater in the case of a motor than in that of a dynamo of similar construction. Should this prove to be the case, it tends somewhat to upset previous ideas as to the relative shape of the resultant field in motors and in dynamos, in which the reverse condition has hitherto been supposed to hold; that is to say, the field of a dynamo has been supposed to concentrate within the core of the armature more quickly than that of a motor, whereas these results may find an explanation upon the opposite assumption. It may, however, prove that the experimental results are peculiar to this special construction, and depend upon the fact of the inaction of a portion of the armature. The point is worthy of further study, as it promises to throw some light upon the outstanding questions as to the difference of the reaction in the fields of motors and of dynamos.

Returning to practical matters, Messrs. Immisch are further about to introduce another special feature of great interest, but as the foreign patents are not yet completed we are not at liberty at present to describe the arrangements. It may, however, be stated that the results obtained will enable a single series wound motor under constant E.M.F. to run at nine different speeds under constant load, or to take nine different loads at constant speed, and this by the movement of a single switch, without the introduction of wasteful resistances, and without overstraining the machine. The arrangement was primarily intended for tramcar work, either in connection with accumulators or with dynamos.

The following table gives the result of some tests of the motor to which we have already alluded as being employed for driving machinery at the Immisch Works.

Table I.

Test of an Immisch Motor, weighing 350lb. Resistance, ·55 ohm.

Speed.	Volts.	Amp.	H.P.	E.H.P.	Efficiency.
920	130	31·25	4 42	5·45	·81
980	134	31·5	4·7	5·68	·83
1080	147	31·0	5·2	6·1	·85
1080	147·5	31·5	5·2	6·2	·835
960	137	31·0	4·6	5·7	·805
999	131	31·5	4·8	5·55	·865
1080	148	31·	5·2	6·15	·845
1090	152	31·5	5·25	6·4	·82

These tests were carried out with a Prony brake, having an arm 2ft. $1\frac{7}{32}$in. in length. The weight on the brake being in every case 12lbs. The resistance of the machine being ·55 ohm, the volts lost in the coils will be $·55 \times 31·5 = 17·3$ volts. If, therefore, there were no losses from Foucault currents, mechanical and magnetic friction, &c., the maximum theoretical efficiency would have been

$$\frac{150 - 17·3}{150} = \frac{132·7}{150} = 0·885.$$

The remarkably close accord between this maximum theoretical value and the values actually obtained is a sufficient proof of the general excellence of the design of these machines, and also shows how little is lost by the short-circuiting device.

The following table gives details referring to the several types which have been selected as standards, but we believe that the company undertake to build machines to satisfy any given practical conditions.

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TABLE II.—Immisch Series Wound Motors.

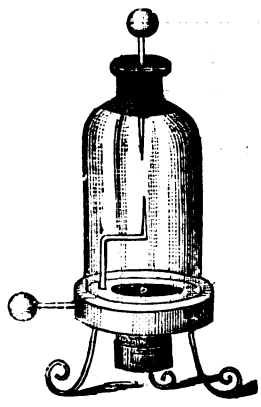
Highest E.M.F. machines are wound for	100 volts.	150 volts.	200 volts.	300 volts.	400 volts.	500 volts.	600 volts.
Lowest E.M.F. machines are wound for	40 volts.	50 volts.	60 volts.	70 volts.	80 volts.	100 volts.	120 volts.
Approx. weight	100lb.	175lb.	350lb.	550lb.	800lb.	1200lb	1600lb
—	SM_4 Maximum Brake H.-P.	SM_5 Maximum Brake H.-P.	SM_6 Maximum Brake H.-P.	SM_7 Maximum Brake H.-P.	SM_8 Maximum Brake H.-P.	SM_9 Maximum Brake H.-P.	SM_{10} Maximum Brake H.-P.
Lowest speed for h.-p. in same line.							
1,800	1·6	4·0					
1,600	1·4	3·5					
1,400	1·2	3·0	8·0				
1,200	1·0	2·5	6·8	12·5			
1,000		2·2	5·7	11·25	20		
900		2·0	5·0	10·0	18	27	
800			4·5	9·0	16	24	37
700			4·0	8·0	14	21	32
600				6·8	12	18	27
500				4·5	10	15	22
400					8	12	17
300					6	9	12
200						6	8

The efficiency of conversion averages from 70 per cent. in a 1 h.-p. motor to 90 per cent. in the 20 h.-p.

For the present we shall have to postpone any detailed criticism upon these figures, but there still remain several points of interest in connection with the work of Messrs. Immisch to which we intend to refer at an early date. In conclusion we must add that the whole of the experimental and mathematical work accomplished during the last twelve months has been carried out under the superintendence of Mr. Albion T. Snell, electrician to the company.

EDUCATIONAL APPARATUS.

The accompanying illustration shows a convenient piece of apparatus which has been designed and constructed by Messrs.



King, Mendham and Company, of the Western Electrical Works, Bristol, by means of which the interesting phenomenon of the deposition of dust and smoke by electric action may readily be produced and observed. It consists of a Bell jar, through the top of which is fixed a brass rod carrying a brass ball at its upper extremity and terminating in a point within the jar. Opposite to this is placed another rod, which passes out through the base of the apparatus. Each of these rods is intended to be placed in metallic connection with an electrode of a Wimshurst electrical machine. The Bell jar is mounted on three supports, and beneath the base is a cylindrical box in metal, in which the fume can be produced. Smouldering brown paper is placed in this metal box, and when the smoke has completely filled the jar the machine is started, and the smoke, which at first appears to be greatly agitated, is observed to be quietly vanishing, leaving the jar perfectly empty.

ON DISTRIBUTING ELECTRICITY BY TRANSFORMERS.*

BY CHARLES ZIPERNOWSKY.

After a brief reference to the several attempts that have been made to overcome the difficulties in the way of lighting a considerable area by means of electricity since the subdivision of the electric light has become an accomplished fact, the author points out that a practical system of distributing electric energy over a large area can only be based upon the use of high tension currents for conveying the energy from the generating centres, in combination with some mode of reducing the high tension to the limits of difference of potential which can be made use of without danger or difficulty. This limit is at present about 100 volts. Many methods have been suggested for meeting these conditions.

Thus a counter electromotive force can be introduced into the high tension circuit, as in the case of accumulators, and the terminals of such a device connected with the lamps, &c. The cost is, however, a great defect of the system, and the high tension current which exists at each lamp might lead to fatal consequences.

After referring to the electric transmission of power as another means of overcoming the difficulty, the author discusses the use of induction coils or "transformers" in some detail, tracing their use in the first instance to C. W. Harrison in 1857. Among subsequent workers Jablochkoff, C. T. Bright, Fuller, Varley, Haitzma Enuma, Gaulard and Gibbs are mentioned; and he points out that the want of success was in great part due to the fact that the transformers were connected up in series, an arrangement which is only suitable for use with an invariable number of lamps in any one secondary circuit, or when each transformer supplies only one lamp.

Besides considerations in regard to cost, the conditions to be satisfied by a system of electric distribution are stated as follows:—

(1) Perfect independence of the several consumption devices.

(2) Absolute and relative economy, so that the consumption of energy is in proportion to the number of lamps in use.

(3) All regulation to be concentrated at one central station.

The author then proceeds to describe the method he has devised in conjunction with M. Max Déri, and, with the assistance of M. O. T. Bláthy, to satisfy the above conditions.

This is based on the fact that, with a constant primary tension, the secondary one will vary only in proportion to the internal resistances of the coils; and as the resistance of each coil is less than 1 per cent. of the external resistance, the secondary tension will not vary more than 2 per cent., whatever be the intensity of current supplied to the consuming device. Constancy in the primary tension at the transformer terminals is secured by connecting them in multiple arc with the main line, and the arrangements are such that current and tension are distributed in the primary circuits, much as in a low tension direct supply system, the transformers simply acting as tension-reducing devices.

Instead of the old Ruhmkorff coil pattern of transformer a form is adopted such that the lines of magnetic force circulate entirely in iron, or as nearly so as possible, by which arrangement a considerable economy of magnetising force is effected and other advantages are at the same time gained. Two forms of transformer made on these principles are described, as well as the self-regulation of alternating current machines, which is especially valuable in installations of moderate size.

This system is at present in use in the towns of Gerona in

* Paper taken as read before the British Association at Birmingham.

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Spain, Lucerne, in Milan, and stations are in course of erection in Turin and Rome. The arrangements for the last named are explained in detail and illustrated by a diagram, and the author concludes by pointing out that, although the last word has not yet been spoken in relation to the distribution of electricity over large areas, the above system is the only one with which he is acquainted that approximates to the fulfilment of an ideal distribution.

ON THE VARIATIONS IN THE VALUES OF SOME STANDARD RESISTANCE COILS.*

The values of the legal ohm standards have been carefully determined for various temperatures. The observations on the coil C.C.L. 100 extending from November, 1884, to January, 1886, are all satisfied by the value ·998770 legal ohm at 12°28 with a temperature coefficient of ·000272 per 1°C., while the values for C.C.L. 201 fall into two series, the one set (November, 1884, to July, 1885) giving a mean value ·998815 legal ohm at 14°15 with a coefficient of ·000259; while the second series gives ·997860 at 10°98 with a temperature coefficient of ·000272 per 1°C. From this it follows that at 12°, during the intervals between the two series of observations the resistance of C.C.L. 101 fell by about ·00015. The low temperature coefficient of series (1) is due to the fact that the high temperature measurements were made some eight months after the low. It is thus necessary to avoid the use of newly-made coils for accurate work, and to test them repeatedly against the standards. Two ten ohm coils were tested. They were made of the same platinum silver wire, ·015 each in diameter. Yet one was found to have a temperature coefficient of ·00289 and the other of ·00312 per 1°C. It is thus of importance to secure accuracy to determine the temperature coefficient of each individual coil used for an important research. Observations on the temperature coefficients of the coils of higher resistance are still in progress.

* Abstract of a paper read before the British Association at Birmingham by R. T. Glazebrook and T. C. Fitzpatrick.

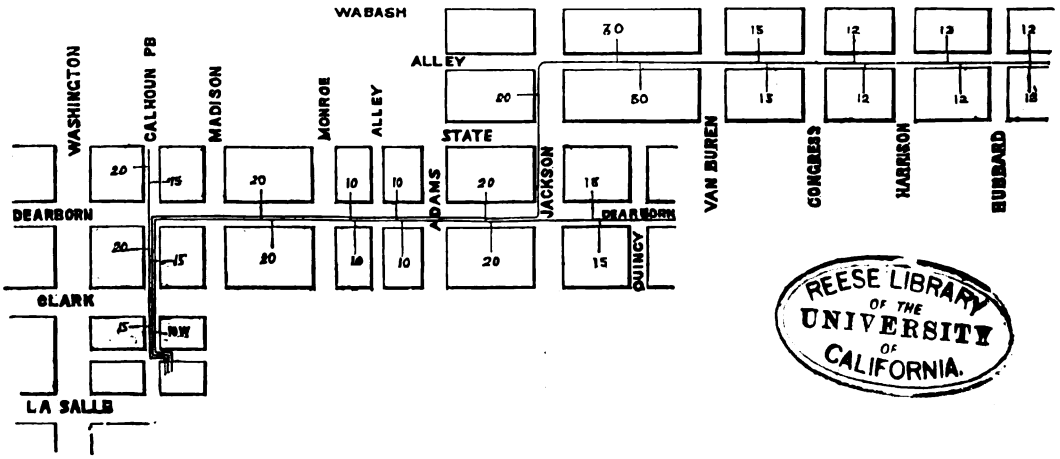
LITERATURE.

Heroes of Science—Physicists. By William Garnett, M.A., D.C.L. [London: Society for Promoting Christian Knowledge.]

Hero worship is, under certain circumstances, commendable, and for all forms of hero worship that paid by intellect to intellect indicates the highest type. The admiration of the animal part of man—to mere brute strength and courage—can hardly be compared with the admiration which is given to intellectual pre-eminence. We are accustomed to restrict the term hero to the victor on the battlefield; but there are other and greater victories than those which lead to the destruction of life. The victories to which we refer are those obtained in attacking Nature's secrets, and wresting them from her grasp, making them for the future subservient to the wants of man. These victors are not understood by the multitude; their work and success only appeal to the few—to those, in fact, who are somewhat familiar with the difficulties to be encountered and overcome in this pursuit of knowledge. Year by year, however, scientific education is spreading, and the number is increasing of those who can appreciate the work of the giant intellects that have in the past stood commandingly out among their fellows as successful labourers in scientific investigations. Prof. Garnett in this work has placed before those who desire it a simple narrative of facts relating to "Heroes of Science" which will conduce to a better appreciation of their services to mankind than has hitherto been the case. Larger books are so filled with details that the prominent discoveries are hidden amongst a mass of irrelevant matter, and fail to make due impression upon the reader. Faraday was like an officer who starts work with a few undersized, immature recruits, and who by energetic work, adds largely to the number, and leaves to his successors a disciplined host of well-developed hardy soldiers. Maxwell takes in hand the disciplined host, and secures for it arms of precision. But enough of generalising, we have to point out what Prof. Garnett has done. His aim is to bring "within reach of every boy and girl material which would otherwise be available only to those who had extensive libraries at their command and much time at their disposal." The "heroes" mentioned are Robert Boyle, Benjamin Franklin, Henry Cavendish, Count Rumford, Thomas Young, Michael Faraday, and James Clerk-Maxwell; and we find, as the author says, "the biographies of a few distinguished men, who by birth were British subjects, and incidental allusions only are made to living philosophers. But, notwithstanding these narrow restrictions, the foundations of the Royal Society of London, of the American Philosophical Society, of the Great Library of Pennsylvania, and of the Royal Institution, are events some account of which comes within the compass of the volume."

It would prove a congenial task were we to dilate at length upon this book; but we think the reader will find it far more pleasant to peruse it for himself. There is not a "hero" mentioned therein but whose work in the realms of scientific investigation will bear the closest study. We may venture to point to the moral which the reading of the life of Cavendish must inculcate. The world asks that the results obtained by original research shall be made as widely known as possible. Can we conceive where electrical science would now stand had Faraday commenced where Cavendish left off, instead of laboriously traversing the same field? Every new fact observed is a step gained, and ought not to be reserved for a moment. While we postpone, time progresses, and if life is allowed to pass while our work is kept back, the work has to be done over again.

UNDERGROUND WIRES AT CHICAGO.



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The accompanying diagram shows the distribution of the wires on the Brooks system, which has just been carried out at Chicago.

The wires are generally taken to opposite blocks for the same splice boxes; but a separate splice box for each block can, if required, be used.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, *Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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EXHIBITIONS AND ELECTRIC LIGHTING.

The epidemic of Exhibitions which has its seat at South Kensington, and which has broken out with increased severity all over the country this year, is, like most epidemics, useful both for warning and instruction. As to any other useful purpose it may serve we prefer to say as little as possible. These Exhibitions have given immense satisfaction to the community at large, and have afforded a vast amount of innocent enjoyment, with possibly a real though not a very large addition to the general stock of practical knowledge. But from the manufacturer's or tradesman's point of view they leave something to be desired—something which has found expression in more than one quarter already, and something else which is perhaps the more vexing because it cannot be easily or safely put into print. The public sympathy is at present entirely with the Exhibitions, and the wisest thing to do under the circumstances is to humour the public fancy, and make as much out of it in the way of business as is possible. At one time the promoters acted as though they were conferring a favour on every intending exhibitor. In a great measure this idea has been exploded owing to the indisputable evidence of figures, which show that if anything profits by the exhibits it is certainly the Exhibition, and if anybody loses it is certainly the exhibitors. Balance-sheets to the contrary notwithstanding, it is plain that these Exhibitions pay somebody exceeding well, and that the profits might be available for uses to which at present they are not put.

A conspicuous illustration of what we mean is furnished by the electric light, which has played a prominent part in every Exhibition during the last five or six years. At first, acting in the spirit to which we have adverted above, the authorities required the lighting to be done for the value of the advertisement. This is no longer the rule; and where it prevails, it probably results in an inferior article being supplied by persons who have no other claim to public favour than the publicity to be obtained by gratuitous exhibition. Generally, however, the electric light is now paid for at a fair price, several competitors are allowed to light different sections, and the public can form a judgment, if they care to do so, on the relative merits of rival systems. The main advantage to the electric lighting engineers as a body is that visitors to these displays are familiarised with the new illuminant, appreciate its light and comfort, and establish in their own minds a standard of what good lighting on a large scale ought to be. This undoubtedly is a great service to the electric light, which, it may be frankly admitted, owes more to Exhibition craze than to any other influence whatsoever. On the other hand, the electric light may confidently claim to have given as much as it has received. It has undeniably contributed not a little to the success of the Exhibitions wherever they have been held; and it may be doubted whether the most popular among them—the one at South Kensington—would have proved half so attractive in the evening time, and consequently not nearly so profitable as a place of amusement, had it not been for its decorative splendours of illumination, to which the electric light so readily lends itself.

On this account partly, and partly on the utilitarian grounds which these Exhibitions ostensibly serve, we venture again to urge upon the authorities the duty of doing something more for the electric light than they have hitherto done. We have repeatedly suggested that Exhibitions of this kind offer the best of all means for testing accurately the merits of the various electric lighting systems on view. Nothing of the kind has yet been adequately done, and where it has been attempted the results have proved often illusory and sometimes absurd. Where the appliances are merely there for lighting purposes and not as exhibits of course no such tests can or ought to be taken. But if it were known that the show would award prizes to the best exhibits of electric lighting plant as such, there would be no lack of competitors; and if, as might well be the case, the the prizes were valuable, the test would be proportionately severe, and the final awards eagerly coveted. This is a service which the Exhibition authorities might very easily and very properly confer upon the electric lighting industry, but which up till now they have abstained from seriously carrying out. For a comparatively new industry it is just the sort of duty which one might think would be cheerfully taken up by such a body as that which is responsible for the doings at South Kensington. It is a *quasi*-scientific body, and is never tired of preferring its claims to public favour on the ground of services rendered to science, art, and commerce. Here is a great opportunity of establishing its claims by settling in the public interest a disputed question as to cost of the electric light, its illuminating power, its merits as compared with other illuminants, and the relative merits of the several electrical systems now competing for public capital.

It is still literally true that we are without authoritative data on the above-mentioned important practical points; and until we have them, electric lighting, as an industry, can make headway only slowly, and without that confident support of

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the public which is needful to convert a scientific idea into a working reality. Any Exhibition would serve, provided the judges were well chosen; but none would carry so much weight in public estimation as the voice of South Kensington, and upon none, we make bold to say, does the obligation devolve so naturally. We want South Kensington to do for electric lighting what the Royal Agricultural Society did for the portable steam engine, and what it is now proposing to undertake on behalf of the traction engine—that is to say, to examine with scientific accuracy into the conflicting claims of inventions, and to inform the public as to their cost, efficiency, and relative fitness for special requirements. Undoubtedly this is a task which might be confidently undertaken in the quarter we have named; and as a considerable fund is at its disposal for purposes of the kind here indicated, we trust that action in this direction will not be long delayed. To electric lighting engineers we would say that the lessons of these recent Exhibitions point to the necessity of abstention from exhibits of plant which are not to be tested in a satisfactory manner, and by jurors whose decisions will not be conclusive.

CORRESPONDENCE.

TESTS OF DYNAMOS.

Our contemporary *Industries* commented upon a letter which appeared (and was duly acknowledged) in our columns. The following letter has been sent to the Editor of *Industries*, and a copy was also forwarded to us as likely to prove interesting to those of our readers who have followed the subject.—[Ed. *E.*]

Sir: In your very flattering article on "The Commercial Efficiency of Dynamo Machines" you state that the method was devised by me.

It is entirely due to Mr. H. W. Ravenshaw, to whom it was suggested by Captain Cardew's method of using two dynamos, in which, however, the efficiency of the motor is assumed, or else measured by a mechanical dynamometer.

While the credit of commercial inventions is often absorbed by the firm by whom they are first brought out, I think it is important that purely scientific discoveries should be credited to the actual inventor.

It should be remarked that the tests which you give were carried out more for the purpose of ascertaining the difference between electrical efficiency and commercial efficiency than for determining the actual commercial efficiency of the machine in question. Moreover, the efficiencies were taken, not at the greatest output only, but at various outputs, thus giving the *average* efficiency for different loads.

The result shows that for the size of the machine, namely, a 7½ unit., the difference between the two efficiencies is only 3½ per cent.

The electrical efficiency can be determined in one's arm chair; and for any machine with a given type of dynamo one can determine the commercial efficiency with accuracy sufficient for practical purposes when this difference is known.

I hope shortly to investigate the relative efficiency of a machine when used as a dynamo and as a motor, in order to settle what you describe as a weak point in the method; and this I propose to do by using a machine, whose name had better be withheld, which has an electrical efficiency of 49 per cent., and the commercial efficiency will probably turn out to be 30 per cent. The losses being so great, it is probable that when carefully tested, both as dynamo and as motor, if any practical difference exists, it will be easily detected. The other two machines will be of good efficiency, though of small size.

At the same time I would point out that, as far as the former tests were carried, even in the inferior machines, there was practically no difference in the combined efficiencies as motor and as generator.—Yours, &c.,

Richard P. Trotter.

26th October, 1886.

ON MAGNETIC HYSTERESIS.*

BY PROF. G. FORBES.

Prof. Ewing, in 1885, made a contribution to the science of magnetism which has only lately come into the hands of scientific men, but which is certain to lead to an extension of our powers in dealing with applications, as well as with the theory of magnetism. Lord Rayleigh has already drawn deductions from it in a paper communicated to the *Philosophical Magazine* for August last.

The consequences which I wish to draw from it have reference partly to practical applications, and specially to secondary generators or transformers, and partly to Weber's molecular theory of magnetism.

If a coil of wire carrying an electric current encloses an iron core, whose length is at least 400 times its diameter, or which is of a ring shape, the magnetic induction produced at the middle of the bar, or at any part of the ring, is due altogether to the direct action of the electric current, since there is no free magnetism. In this case the magnetic force is proportional to the electric current.

A curve may be drawn in which abscissæ denote electric current or magnetic force, and ordinates represent magnetic induction. As the magnetic force is increased a curve is traced, but this curve is not retraced as the magnetic force decreases. If the magnetic force reach alternately a positive and a negative maximum a closed curve is traced, and the area of which indicates the work done upon the iron core in a cycle of these operations, just as the area of the curve traced by the steam engine indicator measures the work done by the engine in a complete cycle of the movements of the piston rod.

The nature of this curve shows that we cannot express the magnetic induction in terms of the magnetic force alone. It is also a function of the history of the iron in the immediate past. This phenomenon is called magnetic hysteresis.

A figure (taken from Ewing) shows the increase of magnetic induction from zero to a maximum with increase of magnetic force and the subsequent cycle produced. The arrows indicate the direction in which the curve is traced.

If the iron be subjected during the process of magnetisation to mechanical shocks, these peculiarities disappear and the induction becomes a pure function of the magnetic force. It is generally supposed that the tremors of a dynamo machine prevent the effects of magnetic hysteresis from showing themselves. This may sometimes be the case. It is not always so. In the first model non-commutating dynamo constructed by me the electromotive force did not diminish 10 per cent. after the existing current was reduced to zero. That model consisted of a long cylindrical electro-magnet rotating about its axis, its poles being connected by a soft iron cylinder with closed ends.

In secondary generators hysteresis must play an important part. In this case the magnetising force is due to the sum of the two currents in the primary and secondary coils. Now the maximum value of the current in the primary is reached earlier than the maximum of the sum of the two currents, and the maximum of the secondary currents later. This fact introduces interesting modifications in the form of the magnetic indicator diagram of the two circuits to which I wish to draw attention. I will suppose that the maximum of magnetic induction is coincident in time with the maximum of the algebraical sum of the primary and secondary currents.

The phase of the primary current may precede, and the phase of the secondary current may follow, that of the magnetic induction by a value varying from 0 to $\frac{1}{4}$ when T is the period of a complete cycle. The currents are taken as harmonic functions of the time. To transform Ewing's cyclic curve of hysteresis into the corresponding diagram for the primary or secondary circuit whose phase is $+a$ or $-a$ in advance of the phase of induction, let the maximum abscissæ represent the magnetic force due to the maximum force due to the maximum current in that circuit, and describe a circle with this abscissæ as radius, and the zero of co-ordinates, O, as centre.

Take any point, P, on Ewing's curve. Draw its ordinates,

* Paper read before the British Association at Birmingham.

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P, M. Let this line produced, if necessary, cut the circle in Q Q. This line cuts Ewing's curve in two points, P, P^1. If P be the higher of these points, operate on Q the higher of Q Q^1, and contrariwise. Draw Q Q^1 inclined to O Q at an angle $+\alpha$ or $-\alpha$. Draw the ordinate Q^1 M^1 and cut off P^1 $M^1 = P$ M. P^1 is a point on the new curve corresponding to P on Ewing's curve.

In this manner other figures have been drawn for the primary and secondary circuits of a secondary generator for cases where the acceleration and retardation of phase are $\frac{1}{8}$ and $\frac{1}{4}$.

In all these curves work is done in a complete cycle by the electric circuit on the iron when the curve is traced in a direction contrary to the motion of the hands of a watch, and contrariwise. We can now notice several facts.

1. In all diagrams for the primary circuit the curves are described in the same direction as Ewing's curve, showing that it does work on the iron.

2. In both diagrams for the secondary circuit the curve is described in the opposite direction to Ewing's curve, showing that work is done by the iron on the circuit.

3. When the acceleration of the primary is $\frac{1}{4}$ no work is done by the iron on the primary circuit at any part of the cycle.

4. When the retardation of the secondary is $\frac{1}{4}$ no work is done by the circuit upon the iron at any part of the cycle.

5. In the diagram for the secondary circuit, if the retardation be the angle corresponding to the absissæ, O, A, the curve passes through the origin, and the work done in a cycle is zero.

6. If the retardation be less than this, work is done in the cycle by the secondary circuit on the iron core.

7. It follows from this that owing to magnetic hysteresis the retardation of the secondary current cannot be less than the angle corresponding to the abscissæ O A, except in so far as it derives energy by direct induction from the primary.

In most early attempts to make secondary generators the mutual induction of the primary and secondary coils was very slight, and here the retardation must be at least equal to the angle indicated.

These remarks hardly apply to Gaulard and Gibbs's secondary generator, who made it a commercial success mainly by causing the direct mutual induction of the circuits to be a maximum.

Lord Rayleigh has pointed out that since hysteresial dissipation of energy per unit volume of iron is the same whether the magnetic circuit be opened or closed, while the total work done on or by the electric circuits is greater with an open magnetic circuit, therefore the most efficient secondary generator is one with an open magnetic circuit. This is only when hysteresial dissipation is the only cause of the loss of efficiency. It has appeared, however, that in actual secondary generators hysteresial dissipation is but a portion of the cause of the loss of efficiency. Resistance of the generator itself is a principal cause, and the loss from this cause varies as the square of the current, and would be much greater with the high currents proposed by Lord Rayleigh for his elongated elliptical iron core than in a secondary generator with a closed iron magnetic circuit. The efficiency which Lord Rayleigh proposes to gain in hysteresial dissipation is proportional to the current. The loss due to resistance is proportional to the square of the current.

Throughout this investigation I have assumed that magnetic induction does not lag behind the magnetic force.

The second part of this paper has relation to the molecular hypothesis. This hypothesis, as developed by Weber and Maxwell, gives no account of hysteresis. Ewing has proposed a further assumption, that a molecule has a friction (not a viscous friction, but what Maxwell called striction), which prevents it from turning until the turning force exceeds a constant value.

It seems to me that the fewer assumptions we make the more near to the truth are we likely to be. Weber has made the assumption that a constant force tends to restore the molecule to its original position. The simpler assumption seems to be that in ideally soft iron the molecules take up positions depending upon the influence of the others. I suppose that when there is no magnetisation the molecules naturally group themselves in pairs with poles of opposite name in juxtaposition, and that the value of the resolved part of the magnetic force required to separate them must reach a certain value, K, before any deflection takes place, and then the deflected molecule sets itself in the direction of the magnetic force. This seems to be a very likely hypothesis for iron of ideal softness. If H be the magnetic force, and θ the inclination of the axes of a pair of molecules to the magnetic force, the molecules acted upon and set with their axes parallel to the direction of the force are those for which $\sin\theta$ is greater than $\frac{K}{H}$. The number of these varies as the magnetisation. Calling the magnetisation I, we have

$$I = \int_{\sin^{-1}\frac{K}{H}}^{\frac{\pi}{2}} a \sin\theta \, a\beta = \frac{\alpha}{H}\sqrt{H^2 - K^2}$$

for magnetising forces less than H = K, I = O, for other values we have

H = K	I = 0
= 1·2 K	= ·55
= 1·5 K	= ·74
= 2·0 K	= ·86
= 5·0 K	= ·98
= 10·0 K	= ·995

The curve deduced from this has the characteristics of extremely soft annealed iron. The only want of resemblance is the suddenness in the rise of the curve after H has reached the value K. This would doubtless be smoothed by any want of perfect mobility of the molecules, such as is involved in Maxwell's addition to Weber's hypothesis, which must be taken into account in explaining the behaviour of steel, which has no connection with the cause of hysteresis.

After a certain magnetisation is attained the magnetisation of the iron (if there be no demagnetising influence of ends) must retain each molecule in its axial direction, and the demagnetisation cannot commence until a reverse magnetic force is applied.

The effects deduced from this hypothesis are the same in character as those deduced from Ewing's friction hypothesis, but it seems to me that perfect mobility rather than friction is more likely to be the explanation of a property specially possessed by the softest kinds of iron, and I have thought that the hypothesis is at least worthy of consideration.

EXPERIMENTS ON THE MELTING PLATINUM STANDARD OF LIGHT.*

BY CHARLES R. CROSS.

We have been favoured with an advance proof of this paper, which is as follows:—

Notwithstanding the fact that the amount of light emitted normally by a square centimetre of platinum at its point of solidification has been adopted as a standard both by the International Electrical Conference and by the United States National Conference of Electricians, but very few experiments have been made to determine whether it can be made reliable and capable of practical use. An approach towards giving the method a practical form was made by W. Siemens,† who proposed to substitute the light emitted by a given area of platinum at its melting point instead of at its point of solidification, and suggested a means by which, with this modification, the standard could readily be utilised.

The following experiments resulted from a conference of a portion of the Committee on Standards of Light appointed at the Electrical Conference at Philadelphia in 1884.‡ They had for their object the ascertaining of a single fact, viz., the amount of the average deviation which would arise in a series of measurements of

*Contribution to the American Academy from the Physical Laboratory of Massachusetts Institute of Technology. Presented June 16th, 1886.

† *Wied. Ann.*, 1884, Vol. XXII. p. 304.

‡ Messrs. J. Trowbridge, E. C. Pickering, and C. R. Cross.

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the light emitted by a strip or wire of platinum of given surface when at the melting point.

A few preliminary experiments were made by the writer, in which a measured length of fine platinum wire, four one-thousandths of an inch in diameter, was placed at one end of the bar of a Bunsen photometer, with a gas jet shining through a limited aperture at the other end. A current from a small hand Gramme machine was carried through the wire, which was made to glow more and more brilliantly by increasing the speed of the machine. Following the method of Siemens, the greased disc of the photometer was moved farther and farther from the incandescent platinum, so as to keep the disc uniformly illuminated, until finally melting occurred. The last reading of the position of the disc gave the illuminating power of the wire at melting. An unexpected constancy in the results was found, so that it seemed worth while to make a longer series of such observations, which was done in the following manner :—At one end of the bar of a greased disc photometer 200 centimeters (78·74in.) long was placed a circular aperture, through which shone the light of an Argand burner. A platinum-wire lamp was constructed, in which a given length of wire was stretched between two fixed knife-edges, and held by clips, thus allowing of speedy adjustment of the wire. The disc used was furnished with two mirrors inclined at 45° in the usual manner, and it was always placed so that the two sides as seen by reflection appeared alike—a method of measuring much more satisfactory than the one commonly employed with the Bunsen photometer. The length of wire used was measured between the edges when cold, and allowed to expand freely. An attempt was made to use a slit of given length in front of a longer wire, which was abandoned owing to errors arising from inequality in the length of that portion of the wire whose light passed through the slit when the wire expanded. The use of a small weight stretching the wire tight, as suggested by Prof. Pickering and employed by him in a small lamp, presents some advantages, but was discarded from fear of elongating the wire and so causing it to break before complete fusion was reached. Melting was brought about by the use of a slide-resistance of German silver wire in circuit with the platinum wire and a dynamo machine. The variable resistance of the slide was lessened until the platinum wire melted, the photometer-disc being meanwhile moved repeatedly, its final reading giving the light emitted by the platinum in terms of the light emitted by the aperture opposite.

No attempt has been made in these experiments to determine the absolute illuminating power of the wire, but only to ascertain whether ordinary commercial platinum wire has any practical value for use as a primary or a secondary standard.

Two different sizes of wire were used, whose diameters were ·004in. and ·006in. respectively. Wire from two different makers was also used, ordinary wire drawn without special care being taken because of its availability. The length used was always the same when cold, viz., two inches. A very large number of measurements were made, chiefly by Messrs. F. H. Crane and H. E. H. Clifford, students in the laboratory, and careful and accurate observers.

Five sets of observations on successive fusions of wire were made by each observer, and the mean taken. The mean and the average deviation from the mean of a long series of such sets were then found. The tables give the results of the measurements. In all cases the distance between the opposite lights is 78·74in. (200cm.), and the diameter of the aperture in front of the gas flame ⅛in. The recorded distances are measured from the aperture.

In order to give an idea of the degree of concordance of the separate individual readings, the following sets (Table I.) are taken at random. The numbers given are the final positions of the disc, in each experiment, in inches.

TABLE I.

Diameter of wire = ·004in.

Observer *M.*	Observer *N.*
43·7	43·6
43·6	43·7
43·7	43·7
43·6	43·5
43·5	43·8
Mean 43·62	Mean 43·66

A change of 0·1in. corresponds to an absolute change of 0·007 in illuminating power of opposite light = 1·1 per cent.

Diameter of wire = .006in.

Observer *N.*	Observer *N.*
37·7	37·4
37·8	37·2
37·4	37·4
37·2	36·8
37·2	37·2
Mean 37·46	Mean 37·20

A change of 0·1in. corresponds to an absolute change of 0·01 in illuminating power of opposite light = 1·0 per cent.

Table II. is given at length as indicating more clearly the variations among consecutive sets of measurements. I. P. denotes the illuminating power of the platinum wire in terms of that of the opposite light. The average deviation of I. P. is the change in this quantity produced by an increase in the scale-reading equal to the average deviation in inches.

TABLE II.

Diameter of wire = ·004in. Sample A.

Averages of 5 Experiments. Observer *M.*	Averages of 5 Experiments. Observer *N.*
43·6	43·7
43·7	43·5
43·6	43·5
43·7	43·4
43·5	43·4
43·6	43·6
43·5	43·3
43·6	43·6
43·6	43·2
43·5	43·7
Mean 43·59	Mean 43·49
Average deviation ·06in.	Average deviation ·13in.
I. P. = ·650.	I. P. = ·657.
Average deviation I. P. = ·004.	Average deviation I. P. = ·009.

Tables III. and IV. give the means of the various sets of experiments. Column 1 shows the sample used ; 2, the mean of the series taken ; 3, the number of observations from which the mean is derived ; 4, the observer ; 5, the illuminating power ; 6, the average deviation in inches ; and 7, the average deviation in terms of the illuminating power. It will be seen that the maximum average deviation in I. P. for the finer wire is 1·7 per cent., and for the coarser wire 1·6 per cent. of the total value.

TABLE III.

Diameter of wire = ·004in.

Sample.	Mean.	Number of Obs.	Observer.	I. P.	Av. Dev. Inches.	Av. Dev. I. P.
A	43·59	50	*M*	·650	·06	·004
A	43·49	50	*N*	·657	·13	·009
B	43·77	50	*N*	·638	·11	·007
B	43·70	50	*M*	·643	·16	·011
B	44·86	50	*N*	·570	·18	·010
A	45·16	50	*N*	·553	·12	·007
A	43·72	50	*N*	·641	·12	·007

TABLE IV.

Diameter of wire = ·006in.

Sample.	Mean.	Number of Obs.	Observer.	I. P.	Av. Dev. Inches.	Av. Dev. I. P.
A	35·37	20	*N*	1·504	0·15	·024
A	37·19	30	*N*	1·249	0·14	·019

In order to determine the possible accuracy of setting the photometer disc several series of readings (Table V) were taken, in which two apertures through which a gas flame shone were balanced against each other. These readings were taken with apertures of different sizes, in order to test the accuracy of setting in different parts of the scale ; that is, for different relative brilliancies of the lights. Series 3 and 4 were taken so as to bring the disc in the same position as that which it occupied with the ·004in. and ·006in. platinum wire.

TABLE V.

Series.	Number of Observations.	Mean.	I. P.	Av. Dev. Inches.	Av. Dev. I. P.
1	50	31·35	2·286	·076	·019
2	50	31·40	2·273	·054	·012
3	50	43·92	0·628	·042	·003
4	50	36·48	1·342	·044	·005

It appears that the average deviation of the different readings when the opposite illuminated apertures were balanced against each

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other is in general considerably less than that of the readings with the melting wire. The maximum average deviation of I. P. is 0·8 per cent. of its total value; the minimum value is about half as great.

Marked differences in the illuminating power of the platinum wire of the same diameter on different days were observed, contrasting strongly with the uniformity of the results of successive measurements. This undoubtedly arose from changes in the quality, and hence in the illuminating power of the gas, as the height of the flame was kept constant. In future experiments I hope to obtain a more constant standard by using a moderator lamp with aperture, or else by employing the pentane burner.

A consideration of the results given in Tables III. and IV. shows that the light emitted by a filament of commercial platinum at the melting point is quite constant in successive measurements, and it appears to present greater uniformity than many of our commercial standards. There is little doubt, moreover, that by the use of a wire longer, and perhaps of larger diameter, the results would be improved, as there would be less liability to error from the cooling of the ends of the wire by contact with the metal supports (an action, however, which can easily be removed altogether), and from accidental minute inequalities in the length of the wire used. It would also be desirable to use platinum of better quality than is usually found in commercial wire, and to have special care exercised in drawing to insure accurate cylindricity.

It is also evident that such a wire as I have used cannot at best be employed except as a secondary standard, since the ratio of the luminosities of the two gauges of wire employed is not at all in the ratio of the projection of their surfaces.

Still further, a difficulty may arise in the use of a melting platinum wire or strip, even as a secondary standard, from variations in the physical condition of the metal, due to cracking, occluded gases, or other causes. No certain evidence of this was observed with the samples of wire employed, but I am not at all sure that it may not occur with different specimens of commercial wire. From a few preliminary experiments of a series still in progress it appears probable that successive heating and cooling, or continued heating of the wire even under ordinary atmospheric pressure, tend slightly to raise its point of fusion, an action which Edison has shown* to be carried to an extreme degree when continued heating in vacuo is employed. Thus, in one experiment the wire was heated by the current and cooled from one to ten times, and then carried up to its melting point, photometric readings being taken as in previous experiments, with the following results. The wire was ·006in. in diameter. Each value given is the mean of five measurements.

	Mean Reading.
Without reheating	37·65
Reheated once.....	37·42
,, twice	37·42
,, 3 times	37·62
,, 4 ,, ...	37·26
,, 5 ,, ...	37·06
,, 10 ,, ...	37·20

The lesser readings indicate greater luminosity of the melting wire.

In another experiment, the wire in its ordinary condition melted when the reading (mean of five measurements) was 37·8in. After annealing in a Bunsen flame, the mean reading at melting (for five experiments) was 37·2in. After heating to a yellow heat by passing a current of electricity through it for half an hour, the reading at melting (mean of 23 measurements) was 36·9in.

If further experiment should show conclusively that the light emitted by melting platinum is variable beyond narrow limits, it is clear that any photometric standard based on the luminosity of *melting* platinum will present no advantage over those standards now in ordinary use, unless specially prepared platinum freed from gases and consolidated by Edison's process of heating in vacuo is found to be available. Probably solidifying platinum, provided its point of solidification is sufficiently definite, would be free from this objection, although this can hardly be accepted without experimental proof.

* *Proceedings* of American Association, 1879, Vol. XXVIII., p. 173.; Vol. XXII. (N.S. XIV.).

CITY AND GUILDS OF LONDON INSTITUTE EXAMINATION PAPERS.

ELECTROTECHNICS—Course B.

1. Find general expressions for the speed and torque of a motor. Show also that if a shunt-wound motor has a negligible armature resistance its speed will be independent of torque when supplied at constant potential. How does the speed vary with the torque (at constant potential) when the resistance is not negligible?

2. Calculate the "commercial efficiency" and the "economic coefficient" of a shunt dynamo from the following data:—

One revolution of pulley	=3·65ft. advance of belt.
Difference of tension of belt at two sides of pulley	= 684lbs.
Speed	= 764 revolutions per minute.
E.M.F. at terminals	= 110·12 volts.
Main circuit current	= 358 amperes.
Field magnet ,,	= 6·5 ,,
Resistance of armature	= ·009947ohm.

3. Describe fully, with suitable diagrams, the process of testing the efficiency of a dynamo.

4. Write a concise account of the importance in designing dynamos of giving a proper form, &c., to the magnetic circuit. Sketch examples of good and bad designs.

5. Define the coefficient of mutual induction. Why is it sometimes called the coefficient of mutual potential. How is the mutual induction between two coils affected by the presence and form of metal in the intermediate space?

6. Describe the ordinary electrometer method of measuring a high resistance with special reference to the precautions to be taken to ensure accuracy. State and deduce the formula used. How would you modify the method if it were not sufficiently sensitive?

7. Describe, with sketches, some form of pump suitable for exhausting glow lamps; explain its action clearly, and point out how you would use it for the above purpose, and what precautions you would take to ensure a good result.

8. Give, with diagrams, the chief methods of arranging a telephone circuit; and describe the ordinary Blake transmitter and Bell receiver.

9. What are the conditions that a *good* arc lamp should satisfy? Describe some such lamp in which "series," "shunt," and "cut out" coils are used, and state what relative resistance you would employ for these.

ON ELECTROLYSIS.

BY PROF. OLIVER J. LODGE, D.SC.

(Continued from page 500.)

VI.—Addenda.

Electrostatic Calculation of E.M.F. needed to effect Decomposition, (a) *of an Electrolyte,* (b) *of a Dielectric.*—(*a*) I do not think the process is justified by anything Helmholtz has said, but I have allowed myself to reckon through what atomic distances mutual electrical attraction of two charged atoms might be overcome by means of an electrode differing in potential from a liquid by, say, a volt, *i.e.*, by means of a slope of potential of 1 volt in 18^{-8} centimetres.

Let y be the effective distance between two oppositely charged atoms in a molecule, so that the force between them is $\frac{q^2}{y^2}$, and let this molecule come within range of the electrode, and so under the influence of the separating stress $q\frac{dV}{dx}$; then decomposition will be effected when

$$q\frac{dV}{dx}=\frac{q^2}{y^2},\ i.e.,\ \text{when } y^2=q\frac{dx}{dV}.$$

Taking, therefore, $q=10^{-11}$, and $\frac{dV}{dx}=\frac{3\frac{1}{3}}{10^{-8}}=\frac{1}{3}\,10^6$, y comes out 10^{-9} or thereabouts—a very respectable atomic distance. This perhaps indicates that, within molecular range of either electrode, actual decomposition or tearing asunder of molecules may occur, but that through the rest of the liquid the action is propagated in some other way, *e.g.*, by a divorced atom being projected so close to one of the constituents of a molecule as to combine with it in place of its former partner, and so on. In this way two postulates may be avoided—1st, the existence of continuous dissociation in ordinary liquids unexposed to electrical influence, a hypothesis to which I understand chemists see some objections; and 2nd, the attraction of matter for electricity postulated by Helmholtz, so far as it is necessary to the explanation of polarisation. Polarisation would then really be the E.M.F. needed to tear asunder molecules of the given compound within molecular range of the electrode; and automatic interactions of the molecules must be trusted to carry the action forward throughout the whole mass.

It appears that on this hypothesis an E.M.F. of one or two volts would be sufficient to decompose acid water, or other similar compound, if atomic distance were something comparable with 10^{-9}. But it may be considered that the magnitude of this distance points to something like at least incipient dissociation as necessary to electrolysis. Let us find its value more carefully.

Put the problem thus:—To find the relation between molecular distance, x, and the least distance at which atomic electric attraction can be overcome by a slope of potential of 1 volt per x centimetres; on the hypothesis that ordinary electrostatic laws are applicable.

$$\frac{V}{x}q=\frac{q^2}{y^2}.$$

But $$q=1{\cdot}5\times10^{13}.x^3,$$

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and $$3 \times 10^{10} V = 10^8,$$

so $$\frac{q}{V} = 4{\cdot}5 \times 10^{16} \cdot x^3,$$

and $$y = {\cdot}67 \times 10^8 \cdot x^2.$$

The most probable value of x at the present time is, I suppose, $\frac{1}{2}\ 10^{-8}$; and the fact that y comes out so nearly equal to x is at least noticeable.

Distinction between Electrolytes and Dielectrics.—Homogeneous electrolytes and dielectrics behave very similarly when supplied with electrodes at slight difference of potential, but the distinction is that, whereas in an electrolyte the whole of the strain is thrown upon a pair of thin films, the bulk of the medium being as quiescent and unstrained as a metal, in a dielectric the strain exists throughout the medium, sloping steadily down from anode to cathode; if these terms be still permissible. In the one, therefore, the $\frac{dV}{dx}$ strain is excessive, and very small differences of potential easily cause decomposition; in the other, the strain on each molecule is insignificant—there being a whole series of them to share it—and accordingly it takes a great difference of potential to effect decomposition, or disruptive discharge, as it is in this case called, especially if mechanical locomotion of the medium, or a chain of dust particles, be avoided.

In rare gases it seems likely that, by a locomotion of molecules, a steady convective discharge can be maintained, distinct from true disruption; indeed, mobility of particles may play an important part in the giving way of any fluid. But, ignoring this, we can reckon roughly on electrostatic principles how much E.M.F. a given thickness of a dielectric ought to bear; and this is what, at the beginning of the present section, I call

(*b*) *Calculation of E.M.F. needed to decompose a dielectric.*—Let the distance of the plates be z; there will be a series of $\frac{z}{x}$ molecules to share the $V - V'$ between them.

Now, since there are about 10^8 molecules per linear centimetre in a liquid, and about 10^9 in an ordinary gas, the slope of potential in a dielectric will be some 10^{-8}th of what it is in the films of an electrolyte for the same potential difference; and accordingly, since it takes one or two volts to decompose a liquid, it will require one or two hundred million volts per centimetre to burst a liquid dielectric, and a tenth of this for a gas. This is probably much too high—certainly it is for a gas; but then what is one to think about the electrification of the atoms of a simple gas like nitrogen? The hint of Helmholtz occurs to one, that possibly even molecules of elements possess some electric charges; and if one could fancy that the atomic charge in such molecules, instead of being 10^{-11}, was something like 10^{-16}, the experimental value of the dielectric strength of air (viz., 33,000 volts per centimetre) would be obtained, on the preceding hypothesis; and it would vary with the cube root of the pressure.*

Probably, however, one is now not on the right track, and it is better to refrain from further guess-work; though I must just point out that if one reckons the distance at which fully charged atoms would be able to cling together, on this hypothesis, if they are to give ordinary dielectric strength, though it is too great to be reasonable, it is not outrageously so. The simplest plan is, perhaps, just to quote the arithmetic. To reckon the greatest atomic distance when the atoms of a molecule are just being torn asunder electrically. Call it y. The actual stress which can be supported by ordinary air, according to experiment, is given by the equation

$$\frac{V^2}{8\pi z^2} = p = \tfrac{1}{2} \text{ gramme weight per unit of air}$$

so a centimetre thickness can stand $V = 110$ electrostatic units, or 33,000 volts. This would give a force of 110 dynes per electrostatic unit,

or $$110 \times 1{\cdot}5 \times 10^{-11} = 1{\cdot}65 \times 10^{-9} \text{ per atom.}$$

The attracting force of two atoms at distance y, is $\frac{2{\cdot}2 \times 10^{-22}}{y^2}$.

So when a molecule is on the verge of giving way,

$$y^2 = \frac{2{\cdot}2 \times 10^{-22}}{1{\cdot}65 \times 10^{-9}} = 1{\cdot}33 \times 10^{-13},$$

or $$y = 3{\cdot}65 \times 10^{-7} \text{ centimetres, when just giving way.}$$

This is for common air, and is much too big; a stronger dielectric will be satisfied with a smaller limiting atomic range, though still not with one small enough.

It is difficult to suppose that *molecules* tend to get separated instead of *atoms*, and that accordingly ordinary mechanical, not chemical, tenacity is the force to be overcome in a dielectric; for how can this apply to the case of a liquid or a gas?

Consequences of an atomic theory of electricity. Possible electrostatic saturation.—The fact that atoms in electrolytes have a constant charge which is the same for every kind of atom, or at least can only be multiplied by an integor, is so striking that one is constrained to think whether electricity is something necessarily associated with atoms of matter, whether all electrical actions are simple electrostatics among the atomic charges, and whether no quantity of electricity smaller than an atomic charge can exist. The notion is repugnant, but it just wants considering, though I should hardly have ventured to suggest it but for the support Helmholtz has given to the view as at least a possible one (see above). The first difficulty which meets us is the serious one that, since air and gases are not electrolytes, nothing is known about the atomic charges of their molecules. On the atomic theory, however, the unit of electricity is about 10^{-11}, and nothing smaller is possible; so we must provisionally use this as applicable even to air atoms; for it is hardly reasonable to suppose that the aqueous vapour, or other true compound, present is essential to electrostatic actions.

Consider a centimetre cube of air at pressure p dynes per sq. cm.; the number of atoms in it is $\frac{p}{10^6} \cdot \frac{n^3}{800}$ or say $10^{15} p$.

The number in each face of the cube is $10^{-6} n^2 p^{\frac{2}{3}}$, or $10^{10} p^{\frac{2}{3}}$.

The available quantity of electricity of either kind on a face of the cube, *when every molecule is fully polarised*, is therefore,

$$10^{10} p^{\frac{2}{3}} \times 10^{-11} = \frac{p^{\frac{2}{3}}}{10} \text{ electrostatic units.}$$

This is, therefore, the maximum possible density to which an air condenser could be charged, on the atomic theory. If p is a millionth of an atmosphere, this gives 400 volts per centimetre as the maximum possible. If p is one atmosphere, it gives 4,000,000 volts per centimetre. A *liquid* condenser would have 400,000,000 volts per centimetre as its maximum charge. It is to be understood that this calculation has nothing to do with the dielectric strength of the medium. It is not considered whether the medium can *stand* this stress or not; all that is reckoned is the maximum that can possibly be *produced*, on the atomic hypothesis. If every dielectric refuses to stand anything like so much, it is difficult to test the hypothesis; but if the maximum possible were to come out something comparable with what a substance under certain conditions can stand, then it may be possible to try the experiment and to discover some evidence of the existence of an upper limit to the charge a condenser made of that substance is able to receive. One effect naturally suggests itself. If the maximum possible charge is insufficient to burst a given kind of condenser, then that condenser cannot be burst—it will behave as if infinitely strong.

Now, if what I have said has any sense (an improbable assumption) the law of variation of maximum charge with pressure in a gas is as $p^{\frac{2}{3}}$. The dielectric strength of air is ordinarily far below the maximum charge, but if it varies with pressure more rapidly than the $\frac{2}{3}$ power, say as p—it follows that at some high pressure it will overtake the maximum charge and pass above it; and in that case an air condenser at some very high pressure would be unburstable, *i.e.*, the dielectric strength of sufficiently high-pressure air would be infinite. On the other hand, if dielectric strength were to vary, say as $p^{\frac{1}{2}}$, then very low-pressure air would possess this property. Experimental evidence tends to show that, over a moderate range, dielectric strength varies roughly as p; but that at very low pressures this law is largely departed from, dielectric strength rapidly falling to a minimum, and then apparently increasing again as the exhaustion proceeds.

Cailletet found that air at 50 atmospheres was tremendously strong, a millimetre of it being able to resist a powerful induction coil. But it is well known that high vacua are apparently very strong too; though the latter is open to a doubt suggested by Shuster, who does not feel sure that the potential applied to small electrodes is really communicated by them to the gas.

Another mode of attacking the question, whether an upper limit to charge exists, would be by seeking for a diminution in the capacity of a condenser when highly charged. It is generally assumed that the capacity of a condenser is a constant quantity; but perhaps our evidence for this is at present insufficient. The electrostatic permeability of a medium (*i.e.*, its specific inductive capacity) may be found to diminish with high strain, and tend toward zero; in other words, a dielectric may become "saturated with electricity," just as magnetic permeability tends towards zero in a substance very highly magnetised, or nearly "saturated with magnetism." Unless it has been already done, condensers of various material (and air is the easiest) ought to be examined over a very great range of absolute potential; for a departure from the law of simple proportion between charge and E.M.F. could not fail to have an important signification, whether it be the signification I have hinted at or no.

In conclusion, I must confess that the latter portion of this communication has been perhaps too widely speculative; and it behoves me to explain that only a small portion of the whole paper was spoken by me at the meeting of the Association at Aberdeen; and that in ordering it to be printed *in extenso* the Committee have not made themselves responsible for the contents of the whole. I judged, however, that a little latitude would naturally be allowed in the opening of a discussion, and have therefore set down all the matters which, had time and convenience served, I was prepared to bring forward. The preliminary notes published in *Nature*, September 10, 1885, will accordingly now serve as a table of

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* On any such theory, the bursting potential will vary as the number of molecules in a row between the plates, *i.e.*, as the cube-root of the pressure in the case of a gas. This is by no means true for the potential required to *begin* discharge, but it is not hopelessly out of accord with some measurements by Röntgen (*Wied. Elek.*, IV., 465), of the minimum potential sufficient to maintain a discharge already begun in pure dry air, as the following table shows. Though indeed the *fourth* root of the pressure would do better still:—

Minimum Potential.	Pressure.	$\frac{V}{\sqrt[3]{P}}$
639	615	75
577	499	73
503	385	69
402	198	69
301	68	74
258	29	84
198	10·9	90
189	7·1	98
	Mean..	79

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contents. I expect my suggestions to receive a severe and salutary criticism, but trust that my admitted ignorance of much that has been done may be pardoned, for it is to be remembered that I was not called upon to draw up a conclusive report, but to furnish food for reflection and discussion.

LIST OF SUGGESTIONS.

It seems permissible and convenient to print here the list of suggestions issued, soon after the meeting, to the committee appointed by the sections A and B, "for the purpose of considering the subject of Electrolysis in its Physical and Chemical bearings," in case they might aid any member in deciding on a special subject of investigation. Some of the statements have been slightly amended; Nos. 11 and 12 have been added.

1. *Is Ohm's law true for Electrolytes?*—We know that it is roughly true for many electrolytes within certain rather wide limits of possible experimental error, but its *exact* verification for any one electrolyte has not yet been attempted, and it is very important. The question is whether, eliminating all effects due to rise of temperature, the resistance-coefficient of an electrolyte is absolutely constant for infinitesimal, ordinary, and powerful currents. There are two or three plausible ways in which a discrepancy from the exact law may be expected to arise.

(*a*). Supposing the ions absolutely dissociated and to make their way through the liquid according to customary laws of fluid friction, propelled as it were by the electric forces, as is assumed in the theories of Wiedemann, Quincke, Kohlrausch, and others, then so long as the frictional or viscous resistance they meet with varies simply as their velocity, Ohm's law is obeyed. But for very strong currents it is possible that the fluid friction may vary according to a higher power of the speed, and if so, the E.M.F. needed to drive a given current would be a little higher than that calculated from Ohm's law.

(*b*). If the ions are not absolutely dissociated, but exhibit a trace of chemical cling, then some finite though small E.M.F. may be needed to start a current, and thus a violation of Ohm's law may occur in the same direction as that already suggested, but most noticeable with infinitesimal currents. Helmholtz has shown that, for ordinary dilute acid, such an effect, if existent, is almost too small for observation; but in some worse conducting liquids it might conceivably be found.

(*c*). Very viscous or highly resisting electrolytes, such as glass, water, turpentine, &c., may show some discrepancy. In fact, this may be treated as a separate question, and asked thus:—

2.—*Is Ohm's law obeyed by very bad conductors?*—In other words, is the rate of leakage from a charged electrometer simply proportional to the potential with which it is charged, no matter what kind of slight earth connection is established? Polarisation E.M.F.'s are in this case probably too small to have much influence, and so the problem is in some respects simplified. The investigation is, in fact, precisely similar to an examination of the accuracy of Newton's law of cooling.

(*To be continued.*)

ELECTRIC ILLUMINATION OF LIGHTHOUSES.*

BY J. HOPKINSON.

The employment of the electric arc as a source of light for lighthouses has received attention for many years, but no apology is needed for returning to the subject, as the rapid development of electric apparatus brought about by the use of the electric light for other purposes, and the perfecting of new forms of motive power continually introduce new aspects of the question. An elaborate experimental inquiry has recently been conducted by the Trinity House concerning the relative advantages of electricity, oil, and gas as lighthouse illuminants, the actual experiments being addressed mainly to a comparison of the results obtainable in a practical shape by each illuminant in its maximum development, and it was conclusively proved that whether in thick weather or in clear the most powerful light at a distance and the most penetrating in fog could be exhibited from the electric arc. A further inference was drawn from a consideration of estimates of cost of the three systems, viz., that the electric light was necessarily costly, and could only be economical when enormous power was needed. The latter inference is no doubt valid so far as the particular electrical and mechanical appliances considered by the Trinity House Committee are concerned. The question may, however, be looked at from another point of view—given a limited permissible outlay and a limited annual charge for attendance and material, what can be done for the mariner by the aid of electricity?

Let us first see what are the intrinsic advantages of the electric arc. They all lie in great power in exceedingly small compass. The effect of the small size of the arc light upon the power of the light when used with optical apparatus, has been often pointed out, and the accuracy with which positions of danger can be marked by coloured sectors is also familiar to engineers. Less consideration has been given to the fact that it is undesirable to make the brightness of the light at any distance unnecessarily great, as the excessive brilliancy dazzles the eye. It is a desideratum, then, whilst directing as powerful a beam as possible to the distant sea, to avoid throwing more than a moderate illumination on the nearer sea. It is possible to realise this desideratum far more effectually with a small source of light like the electric arc than with any other illuminant; but with the exception of one lighthouse, so far as I know, it has been very partially attempted, the reason being a fear that the proper position of the arc could not be maintained. Almost the only complaint made by the mariner of existing electric lighthouses is that at a moderate distance they are dazzling. This is solely due to the fact that too much light is directed to the sea, or, which comes to the same thing for this purpose, the beam directed to the horizon has, in order to cover any possible error of position of the arc, too much divergence imparted to it. Owing to improvements in lamps and carbons, it is now safe to concentrate the light much more closely upon the horizon, with the double advantage of greater power where the light is wanted and moderated power where excessive power is injurious. This view is fully confirmed by the experience of the two most powerful lighthouses yet erected, otherwise than by way of experiments, Macquarie in New South Wales, and Tino in Italy, both constructed by Messrs. Chance Brothers and Co. The former is a first order optical apparatus, focal distance 92cms., and although the concentration on the horizon is greater than in any previous lighthouse complaints have been occasionally made that the light is too bright at short range.

Tino is a second order 70 cms. focus, and the principle of strictly limiting the divergence and giving a smaller proportion of the whole light to the nearer sea is carried much further. The result is that in clear weather the apparent brightness of the light as seen from the sea increases with the distance, till a distance of eight or ten miles is attained, when full power is reached. By means of the simple optical appliances provided there has never been any difficulty in keeping the source of light accurately at the focus. Experience, then, shows that a specially advantageous distribution of light between the nearer and more distant sea may be obtained with the electric light, provided a large and suitable optical apparatus is used.

Distinction of lights apart, the true measure of efficiency of a lighthouse may be said to be the fewness of the occasions at which it fails to be visible at its advertised distance, subject to the condition that at no distance shall its brightness be an annoyance. This is obtained by greater optical concentration towards the horizon, with limited illumination of the sea, together with the power of widely varying the intensity of the source of the light, conditions which can be better realised with the electric arc than with any other source. The electric light possessing the advantages named, it is its supposed great cost which bars its introduction in many lighthouses.

Why, then, should the electric light be so excessively costly in a lighthouse for any but the very greatest powers, such as are only worth providing for a few important landfalls? The great cost both of first outlay and maintenance appears to arise almost entirely from the fact that the machinery is arranged to supply on each and every night, however clear, an unnecessary amount of power; consequently the heavy machinery always used is remote from the lantern, and it is necessary that two men shall always be on duty, one in the lantern, and another with the machinery. Further, the dynamo machinery selected has been of a costly and cumbrous description. The essentials for a cheap electric lighthouse are that for ordinary states of the atmosphere there shall be provided a plant under the easy control of the lightkeeper himself, and which shall be precisely adapted to produce that amount of light which is wanted in ordinary states of the atmosphere; but for thick weather there shall be provided a much more powerful engine and dynamo, available also as a reserve in case the smaller machinery from any cause breaks down. The occasional machinery may be more remote from the lantern, as it is a small matter to require a second man to work on the comparatively rare

* Paper read before the British Association at Birmingham.

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occasions when the maximum power is needed. A small gas engine and dynamo machine can be placed without any crowding in the room immediately below the lantern, and arrangements can be made whereby the light keeper, whether he is in the lantern or in the engine room, can ascertain at a glance whether the arc is in its proper position, with an error of less than one millimetre. The attendance on the lamp rotating apparatus of the lens (if a revolving light), engine, and dynamo would be easy when the whole is brought together so as to be under observation at once; in fact, the gas engine and dynamo and lamp constitute together a gas burner which, though consisting of many parts, is automatic throughout, and when at work requires nothing but the constant presence of a custodian, exactly as the gas lamp in a lighthouse requires a custodian as a guarantee against failure. The same end, viz., the concentration of the whole mechanical and electrical apparatus, under one pair of eyes could be attained of course in other ways; accumulators could be used, or a petroleum engine; but in order to give definitions and afford facilities for criticism, the better course will be to describe a suitable machinery, state what it will do, what attendance it will require, and what it will cost.

I propose, then, for an electric lighthouse, where small outlay is essential, the following:—A Dowson gas-producing apparatus and gas holder, the generator and superheater being in duplicate, each capable of making 1,200ft. of gas per hour, the gasholder having a capacity of 3,000 cubic feet; an 8 horse nominal Otto gas engine and series wound dynamo machine, placed in a room near the base of the tower, and copper conductors to the lantern, the dynamo having magnet coils divided into sections so as to supply a small current when required; a one horse nominal Otto gas engine and dynamo machine placed in the room immediately below the lantern floor, with gas pipe from the gas holder; one spare armature; current and potential galvanometers and switches; three electric lamps to receive either carbons of 25 mms. diameter, or any lesser size with complete adjustments for accurate focussing; the positive carbon below; one paraffin lamp as a stand-by; an optical apparatus of the second order, 70 cms. focal distance, extending from 29° below the horizontal to 80° above. The cost of this apparatus would depend upon the character of the light it was intended to exhibit. To fix ideas let it be assumed that the light is to be a half minute revolving light showing all round the lighthouse. There could then be supplied a 16-sided apparatus, with pedestal and revolving machinery. Provision would be made in the optical apparatus for giving the horizontal and vertical divergence desired by the same methods successfully used in the lighthouses of Macquarie and Tino.

Two focussing prisms would be fixed to form magnified images of the arc on pieces of obscured glass let into the pedestal floor, so that the keeper, whether in the lantern or in the engine room, can see at a glance the state of the arc, and observe whether it is of proper length with the carbons in line, whether it is exactly at the right height and in the centre of the apparatus. An error of one mm. would be glaringly apparent, and call for immediate adjustment, although its effect would be only a displacement of the beam five minutes of angle. The lantern would be 10ft. diameter with bent plate glass. The cost of the whole of the above described would be materially less than £3,400, the cost of a first order light and lantern with oil lamp and large burners.

Let us now see what result would be obtained. In fine weather the small engine would be used. Its effective power on the brake is fully 1½ horse-power; from this 1½ horse-power the dynamo machine produces considerably over 800 watts, say 800 watts on the arc itself, or 20 amperes through a fairly long arc of 40 volts. Of course the value of this in candles depends upon the colour in which it is measured and the direction in relation to the axis of the carbons. In red light the mean over the sphere would certainly exceed 1,200 candles. In clear weather or in slight haze or rain the beam of this light through the lenses would be much more powerful at the horizon and on the distant sea than any single focus light in oil or gas, or at least would be fairly comparable with anything yet exhibited with oil or gas, whether triform or quadriform. But on the nearer sea the illumination would be reduced, so that no annoyance would be caused by dazzling flashes.

In really thick weather or, indeed, in any weather when there was a doubt as to the visibility at the horizon of the lower power, the large engine would be used under the superintendence of the second keeper. This engine will give ten horse-power on the brake, and there is no difficulty in obtaining eighty-five per cent. of this as useful electrical energy outside the machine, that is 6,340 watts. From this deduct 10 per cent. for the leads and the lamp, and for steadying the arc, leaving 5,710 watts in the arc itself, or 114 amperes, with a difference of potential of 50 volts. Having regard to the fact that the optical apparatus here proposed acts upon a larger portion of the sphere than that used in the South Foreland experiments, that the vertical divergence is less, and that the potential difference is greater, and the current continuous, although less in quantity, we may safely assume that the power of the resulting beam would not be inferior; indeed, the maximum number of watts actually developed in the arc in the lantern in the South Foreland experiments must have been materially less than $175 \times 40 = 7{,}000$ watts.

It hence follows from the South Foreland experiments that in any fog whatever the flashes would penetrate farther than those of any existing gas or oil light. The increased size of crater compared with that produced by the current of 20 amperes, will give increased vertical divergence and so cause the maximum illumination to be obtained at a less distance from the lighthouse. The attendance of two men would suffice for all the duties of the lighthouse, because under ordinary circumstances one only need be on duty excepting whilst gas is being made. The usual course would be that with the exception of from 2 to 3 hours at the beginning of the night, the gas producer would be damped down, and when the small engine was at work the supply be taken from the gas holder. Consider the case of a long night of 15 hours. Immediately before lighting up, the producer would be put to work, and would require occasional attention from one keeper, but not his continued presence. For the first three hours of the night the engine would be using between 230 and 240 cubic feet of gas per hour, and the producer supplying between 1,200 and 1,300ft., so that at the end of three hours there would be a store of 3,000 cubic feet, more than sufficient for the night unless thick weather come on, so that after three hours one keeper only would be on duty at a time, and he would always be in attendance on the light. In the event of a fog the keeper on duty would ring up his mate, who would start the larger engine and set the producer to work, and remain in attendance on engine and producer so long as the weather continued thick. A staff of two is adequate at all times, but it is true that more work would have to be done both by day and night, about two hours in gas making and perhaps one hour in additional cleaning of machinery. It would be a question of expediency, depending on the amount of thick weather to be provided for, whether a third man should be employed, or additional pay be given to two men for the additional work demanded from them. Adopting the latter course the extra attendance would be covered by about £35 a year, with an extra allowance when full power is in use.

The consumption of coal would 4lb. per hour of lighting, of water about half a gallon, of carbons about 4in. per hour, allowing for ends wasted. Comparing with an ordinary first order light illuminated with paraffin the account for lower power would stand somewhat thus:—

Credit.

Oil and wicks and glass chimneys, an expense varying with time and place, but not less than annually.	£85	0	0

Debit.

Coal—9 tons at 25s.	£11	5	0
Wages	30	0	0
Oil and waste	6	0	0
Carbons—1,460ft. at £10 per 100ft.	14	12	0
Extra repairs and contingencies	15	0	0
	£76	17	0

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which suffices to show that the charges would not differ materially from an oil light. The substantial advantage resulting would be that at a trifling cost per hour there is available at any moment a light of the greatest penetrative power.

Various objections may be taken to the arrangements here proposed and collateral points be raised, and it may be convenient to anticipate some of them.

A Dowson gas plant is unsuitable to a lighthouse built upon a rock offering no space beyond that occupied by the tower. True, until there is a paraffin engine burning oils as safe as the oils now used in lighthouse lamps, it is probable that the electric light will be excluded from such stations.

Gas engines and dynamos require a different training of attendants from that which they have acquired with lamps for oil. Again true; but it is also true that starting with fresh men it would be as easy to teach them to manage the electric plant as the highly developed burner now used. Still, no one interested would desire to see the electric light introduced into any service unless the keepers were intelligent and well trained, and the supervision vigilant. Indeed, the electric light should be introduced gradually into lighthouses, though not so gradually as has been the case, giving time for the light keepers and inspectors to gain the necessary experience.

The object of this communication is merely to prove that the minimum cost of an electric lighthouse is not *necessarily* greater than that of an ordinary oil light. The maximum power would not be available if the eight horse engine and dynamo from any cause failed. The engine and dynamo could of course be duplicated at moderate cost, about £400; but this appears hardly necessary, as the small engine, though of vastly less power, is still available. The purpose of the larger light is to reduce the number of occasions on which the light ceases to be visible at a stated distance, let us say to reduce it from 50 occasions per annum to 10. If, on some one occasion, this was not accomplished, the mischief would be the same as if on that one occasion the atmosphere had been a little thicker. The large engine is a complete stand-by for the small one.

A question well worthy of discussion is this. In thick weather is it desirable to direct the maximum illumination to the nearer sea instead of to the horizon? The correct answer to this question will undoubtedly depend upon the particular circumstances of each lighthouse, upon the height of the focus upon the sea, and upon whether the light is for the guidance of the maritime traffic and the protecting an extensive reach of coast, or whether it is primarily intended to mark some point of danger, such as the Wolf Rock, or the Eddystone. The presumption is in most cases against dipping the light; it implies robbing the distant sea. The keeper has to exercise his discretion from the appearance of the atmosphere in his vicinity, or in particular directions, and to decide whether it is impossible that the light is reaching its advertised range; if he judges wrongly he may restrict the range of his lights when it is unnecessary to do so. Some guidance may be obtained from the following conditions: With a second order light, and a continuous current of 114 amperes, practically maximum illumination will extend over a vertical angle of about 20′, and over a greater angle the illumination is not much less; we may, therefore, assume that 10′ below the horizon the illumination is as great as in the direction of the horizon, whatever efforts are made to concentrate on the horizon. If the focus be 100ft. above the water, the sea horizon is distant 11·6 nautical miles, and the range from a ship's deck about 15 nautical miles; but a ray dipping 10′ below the horizon will strike the sea at only 3·2 nautical miles from the lighthouse. If the focus were so changed that the light usually going to the horizon would dip 10′ below the horizon, the light which would usually strike the sea at 3·2 miles, would strike that surface at 2 miles distant from the tower. Probably the wisest solution is to duplicate the larger engine and dynamo, and in actual fog to use both engines and dynamos and both gas producers. The resulting current of 220 amperes not only has the effect of more than doubling the power, but also of increasing to a material extent the vertical divergence. In conclusion, I would repeat the points I seek to establish. An electric light need cost no more either in first outlay or annual charges than a first order oil light of ordinary construction. Economy can be secured by concentrating the machinery used in ordinary weather—*i.e.*, by bringing the engine and dynamo into proximity with the arc. It is a radical mistake to diminish the capital outlay by reducing the focal distance of the optical apparatus.

Discussion.

Prof. Adams, who was invited to open the discussion, begged to be excused on the ground that he had no intention of speaking when became to the meeting.

Prof. Forbes said he would like to emphasise most strongly the remark that was made towards the end of the paper, to the effect that it was false economy to think of trying to diminish the optical part of the apparatus, because they had so perfect a focus in the electric arc lamp. He remembered his attention being called to that fact by Mr. Thomas Stevenson, of the Northern Board of Lighthouses, that gentleman having upheld that view from the first. When the electric light was first introduced, one of the most important points that its advocates mentioned was that they might have the optical apparatus made to the size of a hat, because of the small focus. The long focus optical apparatus which they used in oil lamps and gas lamps, and which improved them so enormously, was capable to an equal extent of improving the electric arc lamp; and he wished most emphatically to support the opinion expressed by Dr. Hopkinson that the optical arrangements for the electric light should be of as long a focus as they were for oil and gas.

Prof. Barrett said he had had no experience of the value of the electric light in lighthouses, and therefore he did not quite understand why he had been called upon to address the section; at the same time, he could not disguise the fact that he had had some experience of the value of gas for lighthouses. If it was not out of order, therefore, to refer to the subject, he might mention that during the last autumn and winter Mr. Wigham gave him the opportunity of witnessing the extraordinary effect of his double quadriform, and it so happened that on both the evenings when the experiments were being conducted a fog intervened between the position in which he was placed and the lighthouses. On the second evening the fog was so dense that the fog siren erected there, and which was driven by a gas engine, could not be heard. That he regarded as a very remarkable circumstance, because he did not think there was any evidence that the electric light would penetrate fog of sufficient density to extinguish the sound of a fog siren; but there was no doubt whatever that the double quadriform was veay clearly seen, and that the whole shape of the light could be made out very well. He thought that one of the most striking features of the light was the diffused glare cast on the sky, which would create an impression on the eye, even when the electric light could not be seen. The experiments at Shoeburyness he had no doubt were conducted with great care, but so far as he could judge they were not pitted against the highest forms of gas, and it would be very desirable in his opinion that there should be comparative experiments made between the highest forms of gas light and electric light for the purpose. It was a pity, indeed, that the very best form of the arc light and gas light had not been tested on that occasion, to settle the question once for all. He knew that it was generally believed that in a fog of uniform density the electric light had the greatest penetrating effect, but in a fog of alternating density he fancied that if gas could be lighted from the pipe, whereby a large amount of energy could be liberated in a short space of time, then such a system in a fog might be even more effective than the electric light. With reference to the kinds of fog, he knew that the law being worked out showed the intensity of the light in a fog of uniform density, and here came into play the advantage of a large diffused light such as that given by the double quadriform light.

Mr. Wigham most heartily concurred in what had been said in the paper and also by the gentleman opposite (Prof. Forbes) with regard to the advantage of using a large optical apparatus in connetion with the electric light. He was exceedingly glad to know that so high an authority as Mr. Thomas Stevenson, of Edinburgh, should have pronounced in favour of the long focus lenses. He had before advocated their use, and he was greatly pleased to think that they had been adopted. With respect to the question of first cost, he ventured to express the hope that Dr. Hopkinson was quite right in his calculations, for he (the speaker) thought that this was a most important part of the question. It was very desirable that they should endeavour to reduce the expense in connection with such powerful lights. Dr. Hopkinson's method of doing it seemed promising, and, if that gentleman could also arrange the electric light for lighthouses in the way which he proposed to do—that was to say, by increasing the intensity of the illuminant in thick or foggy weather and diminishing it in clear weather, and as a natural consequence thus diminish the cost—it seemed to him (the speaker) a most reasonable course of proceeding. He took exception, however, to what Dr. Hopkinson mentioned as an undoubted fact that in the South Foreland experiments the electric light in clear or in foggy weather was found to be superior to the other illuminants tried. He happened to be present on one or two of the occasions when the experiments were being made, and the electric light in clear weather seemed to him to be surpassingly splendid, and conveyed the idea that it could not be beaten under any circumstances; and yet, notwithstanding that brilliancy, which was so great that at two miles distance one could read by its aid the smallest print and see the second hand of a watch, when the fog intervened one was surprised at the enormous extent to which it had been reduced by that circumstance. Mr. Dixon, than whom he supposed there was not a more careful and accurate manipulator and observer living, stated that the electric light in fogs at South Foreland was, he thought, about 16 per cent. greater than tha [of gas or

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oil. Prof. Adams, he thought, on the contrary, told the British Association last year it was 60 times greater. Now 60 times greater was a very large percentage, very much larger than 16 per cent., so that between even scientific gentlemen there was a wide divergence of opinion as to the extent to which the electric light in fogs exceeded other lights. But under these circumstance, and especially under the circumstances referred to incidentally in the paper, that the electric light at South Foreland was not directed to illuminate the whole of the horizon as an ordinary lighthouse light would do, but was directed—not always, but on some of the occasions recorded, and on which this percentage of superiority was based—where the position of the observers was known, and where the electric beam was thrown upon them—when that was taken into consideration, as well as the very small percentage which the electric light showed, according to Mr. Dixon, not to speak of the difference of scientific men as to that percentage, and when it was also remembered that at the present moment, owing to questions and requisitions made in Parliament, the Board of Trade had promised to publish the correspondence which had taken place with all their authorities, and with shipowners and others who were not quite satisfied with the experiments at South Foreland, he thought it would be well for the public to withhold its judgment, and not to accept as an undoubted fact that the electric light was more powerful for lighthouse illumination than gas.

Prof. W. Grylls Adams said that there were one or two remarks which fell from Prof. Barrett and Mr. Wigham with direct reference to his own report as to the South Foreland experiments that he felt bound to ask the indulgence of the meeting for a few moments in replying to them. Prof. Barrett, in commenting upon the experiments in Ireland, said that when the fog was intense the fog siren could not be heard—that it could not penetrate through the fog. Now he (the speaker) was astonished at that, because he thought if they had a very thick fog indeed, still the sounds would spread perfectly well—that the fog, in fact, became the medium of the sound, which it conveyed from one point to another, and therefore, provided that it was tolerably homogeneous, the sounds would certainly not thereby be shut out. He did not know whether the idea was meant to be conveyed that the fog siren would be nowhere in comparison with the electric light exhibited on the occasion, but he thought that the general conclusion at which previous observers had arrived was that for near distances—not, say, more than two miles from a lighthouse—in the very thickest weather no light whatever would penetrate that fog, and then they were dependent on the fog siren for the protection of the shipping in the neighbourhood. The experiments which had been made proved that fog conveyed sound remarkably well. It depended, in fact, on the homogeneousness of the fog. With regard to Mr. Wigham's statement as to the difference between his (the speaker's) report and Mr. Dixon's, there was a little mistake as to the facts of the case, for Mr. Dixon did not state that the electric light was only 16 per cent. better. That, he thought, was the result of the general observations made, and he thought that they emanated from the members of the Trinity House and not from Mr. Dixon's report—in fact, from the observations made by unskilled persons in various parts whose reports had been sent to the Trinity House. With regard to his own report and that of Mr. Dixon, he must say that they agreed wonderfully in respect to the intensity of the electric light in different states of weather. There was not what might be called any serious disagreement between the two, as might appear from what Mr. Wigham had stated. He thought that Mr. Wigham's own figures would bear him out as to the difference between the intensity of the electric light and that of any other light, namely, that it was 60 times as bright as that which any other illuminant gave. Mr. Wigham himself stated that at very great distances from the lighthouses, for instance, the light was so intense that they could see to pick up a pin.

Mr. Wigham: Sixty times greater in the fog, you said.

Prof. Adams replied that it depended on the character of the fog. He did not think that he stated it so in his report. A small portion of the report taken without regard to the context might not represent the case as it actually stood. The results which he gave were the results of definite measurements of intensity of light—not any assumptions whatever, but simply the result of measurements—and the whole matter was fully discussed in the report, to which he would draw attention, and he thought it would be found by all who consulted it that there was no essential difference between Mr. Dixon's report and his own; in fact, they were both astonished to find so close an agreement between the results. Of course Mr. Dixon's report referred to one series of experiments made on one night, and his (the speaker's) to a series conducted on another night, so that they might appear to be very different. But it was very easy to contract a leaning in one direction or another without being conscious of any such leaning. He thought, however, that if the whole of the reports were gone through—the general result of his work and that of Mr. Dixon—it would be found that there was a very remarkable agreement between them, and that at any rate they would form a scientific basis from which any one would draw correct conclusions, because there were figures given as to the intensity of the light, and so on, as well as the circumstances under which the experiments were made.

Sir Wm. Thomson said he was sorry that he was not present during the reading of the paper, but he could see from the short abstract of it that Dr. Hopkinson's proposal was one of very great weight, and one from which they might hope to see satisfactory results in practice. With reference to the power of electric light, he did not know whether an erroneous impression which had got abroad from observing the lights on the Thames Embankment had been completely dispelled. Those who were scientifically engaged with electricity had, he thought, got rid of any wrong idea they might have entertained as to the relative power of the electric light and the other ordinary lights; but he did not know that the result of their investigations had been as yet quite appreciated, because he thought that many people were still under the impression that the electric light was less powerful for penetrating fog than gas, so that though the former might be greatly superior in favourable circumstances—when there was no fog—there was still an idea that it lost that superiority in fog. He thought he was right in saying that the result of the investigations of the president and those referred to by Prof. Adams generally had been to show that there was no discernible difference between the penetrating power of the electric light and gas light in a clear white fog.

The President: A very small difference.

Sir W. Thomson: Fogs at sea were white in character, not that kind of fog that they were all familar with in London, Glasgow, and Birmingham, in which the substance that consumed the light—converted the light into heat he should say—was not particles of transparent water, but sooty particles. When the fog was such as to redden the sun or moon seen through it, then, in relative comparison of power, gas or oil would have the superiority; but when the fog was such as to leave the sun or moon white as seen through it, there would be no sensible difference or no difference at all between them. Lord Rayleigh had given a practical mathematical explanation of the absorbing power of fog upon light, and had shown how it was that there should be no difference in the case of a white fog, although there ought to be a large one in the case of a smoky fog. There was one point, however, which Sir James Douglass might probably answer. In the first place, Lord Rayleigh's proposition that there was no loss at all in a white fog seemed startling. The whole light on lighthouses passed away as light, and none of it, or but a small proportion of it, was converted into invisible heat. The light itself became invisible as a point, because of its scattered effect, but the light was all there. The result was this, that the loom of the electric light in a fog, though not visible as a point, might still be most valuable to the mariner. In fact, when the light itself could not be seen at all, a general lighting of the sky in the direction of the light would be visible, and would give the light wanted by the mariner. So that even when the light was not seen practically at all there was still the same relative superiority of the electric light over gas, and if the electric light gave sixty times as much illumination as the oil light, at a distance where neither the one nor the other could be seen, the electric light would have sixty times the power of illuminating the sky. He would like to ask whether the loom of the light on the sky was largely of practical importance in navigation. He could not say whether it was or not; it certainly was in certain other conditions. He thought, from what was stated in Dr. Hopkinson's paper, that they might fairly hope that in point of economy, as well as in point of its great advantage in case of fogs, the electric light would commend itself more and more as a scientific result, which was now ready to be put into practical form and taken advantage of very much more than had hitherto been the case.

Mr. W. M. Mordey was understood to ask whether it was not the fact that in the French lighthouses, where the electric light was used, they employed continuous instead of alternating currents for their apparatus?

The President: Both.

Mr. Mordey said that this was a point on which he wanted information—namely, the cause which had led Dr. Hopkinson to recommend the use of continuous currents. He was glad to see that Dr. Hopkinson did recommend that course, because, like most practical electricians, he had a prejudice against alternating currents for most purposes. He believed there were some practical advantages for the use of alternating currents. The distribution of the heat in the arc was more even, for instance, than it was in the case of the continuous current. The heat was greater at the positive carbon, and the other carbon was similarly affected, and with the continuous current there was a flame much more difficult to deal with than was the case with the other current. As the point was mentioned in the paper which had been read, and was of some practical interest, he would be glad to get some information upon it.

Prof. Barrett remarked that he did not intend to say that a gas lighthouse was superior to a fog siren in all cases, but what he said was that on the particular evening on which the experiments were made the fog siren was not heard at the place of observation though they had listened for it, and the light of the quadriform was seen. The fog was probably not homogeneous. They knew it was dense round the lighthouse because all the lights were on, and it was dense round the place at which they were making observations six miles off, because they could not see neighbouring lights, but the intervening space might have been clear, and in a light of that description it seemed as if the quadriform light was superior to a fog siren. There was another fact that he wished to emphasise, and that was that gas could be usefully resorted to where they could use a large amount of energy suddenly—that was to say, by a sudden large flare of gas at periodical intervals, which ought to be seen at great distances.

Mr. Swan said that if there was any value in Prof. Barrett's suggestion of using a large gas flame, he thought that it was quite possible that a similar effect might be obtained from an electric accumulator with the electric light. If it was a desideratum for the economisation of the apparatus that intermittent effects should be produced in the manner which Prof. Barrett suggested, very similar effects might be produced through the mediation of an electric accumulator.

Mr. C. H. W. Biggs remarked that there was a reason why a certain admiral did not fire a salute, and perhaps there was a cause why the siren was not heard on that particularly bright night. Was there any proof that the siren was going on the occasion in question?

Mr. Kenward (who had read the paper in Dr. Hopkinson's absence), replying to the question put by Sir William Thomson, as to whether any practical results had been obtained from the luminous glare on the horizon from the electric light, said that he could quote one instance where such an effect had been of considerable service. At the present moment the largest lighthouse apparatus in the world was that at Sydney Heads, which was known as the Macquarie light, and which had been erected by the

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enterprising colony of New South Wales. With regard to that light, mariners had reported that the luminous glare had been seen from it at a distance of sixty miles, and had been accordingly of great use to vessels far off, which had thus been able to get a sort of *avant courier* of the direct beam of light.

The PRESIDENT said that before calling on the section to accord a vote of thanks to Dr. Hopkinson for his very valuable paper he would offer a few observations. He did not think he was intruding on his hearers at the present time, as he had been a great many years connected with light-house engineering, and as he was connected with the South Foreland experiments, and as he was so ably assisted in a portion of the work by Prof. Adams, by Mr. Harold Dixon, Mr. Vernon Harcourt, and others, he would make a few remarks on what was done there, simply because the experiments conducted there had been referred to in connection with the paper read. Dr. Hopkinson had brought forward a very important subject in connection with the electric light as applied to lighthouse illumination. Dr. Hopkinson had attempted to show them (he was not sure that that gentleman had succeeded, however, although he assured them that it was a fact) that he was able under nearly all conditions of ordinary lighthouse illumination to compete with oil and gas by electricity. Dr. Hopkinson had entered upon a thorny path, because it was one of the most difficult applications of lighting to compete with. It must be remembered that in such a task they were dealing with very small installations, and in all cases they were dealing with an individual installation and a smallish one. They were dealing with it in an isolated position, in some cases of great difficulty. They must all be aware that mineral oil was difficult to compete with, if for no other reason than because of its cheapness. He remembered the time when they used to pay 6s. 8d. per gallon for sperm oil, but they were now able to obtain an oil greatly superior to the sperm for sixpence a gallon, and therefore that was a bold man who said he could illuminate a lighthouse by electricity as against oil at sixpence a gallon. What had occurred in connection with the South Foreland experiments was this. They had with oil and gas gone to powers ten to sixteen times greater with a single illuminant than they had a few years ago—so recently, in fact, as the French Exhibition of 1867. Electricity had been going on in a greater ratio, and it was now determined by those who had charge of the experiments at the South Foreland—by the Trinity House—in which scientific men from all parts of the country agreed, that at the present moment gas and oil reached an intensity of illumination to meet the ordinary requirements of the mariner. In narrow waters they could very easily overdose the mariner with light, and there were instances on record where the seamen had asked for the intensity of the light to be reduced. Of course that was never said in thick or foggy weather, but in clear weather it was not necessary to have so great a light. Of course, as they had been told, they might as well attempt to compete with the electric light as an illuminant as to expect that a single candle would compete with the sun. It was out of the question to talk of competing with electricity by means of oil and gas, although they had progressed so far that both oil and gas were far ahead of what they used to be. Again, they had an intensity 200 times the initial intensity per square inch of focal area. Therefore, anyone could appreciate the advantage of the electric arc. It was quite true, as Mr. Wigham had observed, that the apparatus at the South Foreland was focussed on the observers, but it must be remembered that the apparatus there was experimental, and therefore it had not time to be seen but from particular points of observation. But that was one of the merits and not one of the sins of the electric light, because they had thus a small arc which they could adapt to special circumstances, and by which they need not rob the mariner of any portion of the light which they were giving him in thick weather. In other words, the utmost intensity of the light could be directed to the position in which it was necessary. Prof. Barrett referred to the case on the Irish coast where the siren was not heard when the gaslight was seen, but all that he (the speaker) had to say in reply to that was that it must have been a very poor siren, because a siren should be heard in any circumstances during fog at a distance of two or three miles. It was quite true that it was one of the most disappointing instruments that he had ever anything to do with. They had sirens at work where they had 150 horse-power put into the sound, and yet that sound at times was not heard a mile away, generally in fogs, but frequently, on the other hand, the sound was heard 10, 12, or even 20 miles distant. There were times when it was not heard at two or three miles. But this occurred at the South Foreland—he did not ask the Section to believe him, but he asked them to look upon him as a disinterested observer—on one occasion during a thick fog they were turned out, as they were subject to be at any hour of the night during thick weather, between one and two in the morning, and they found that they had to walk up to within nearly half a mile of the lights before they could see them. At the moment they were hearing the South Sand Head sound at a distance of three miles clearly. Well, it occurred to him, why should they waste this light, when one of their feeblest sirens, with only 1½ horse-power, was giving them an intelligible sound at such a distance. Several vessels in the offing near to them were heard distinctly, so that it must have been a very different state of things, or the instruments must have been different. Another point was referred to, he thought, by Mr. Wigham (and it was not the first time that it had been referred to) on which he would like to say a few words. It was this. When they commenced the experiments at the South Foreland it was intended that each of the illuminants, mineral oil, gas, and electricity, should do its very best. Mr. Wigham suggested four lamps, a superposed apparatus and four elements, four of the largest burners for lenses, all superposed, and they prepared three for the electric light. They expected at the time that they would place all their energy in one arc. It was thought desirable to determine the question whether it was most economical to place all the light in one, or in two, or in three arcs. They soon found that they could work the one electric arc with all their energy most efficiently in one focus. And the apparatus referred to to-day of the second order—750 millimetres focal distance—had been decided on for the present. That, he might remind the Section, was a very important question. It was not absolutely necessary that they should have a second order apparatus for the electric arc, and not that he would say that the second order of apparatus was right. The French had gone from the fifth order to the sixth, and probably they might go further, but this he thought unnecessary. It was very desirable for the manipulation of the light that the keeper should enter the apparatus, and the second order size was just sufficient. If the second order size with such a pair of carbons (shown) would meet their requirements as to the necessary duration of the flashes (if they had not the necessary length of flash they would, of course, require a smaller apparatus), and if that were sufficient to meet all requirements, any enlargement of that apparatus was a positive waste of money. With regard to the question of direct and alternating currents referred to by another gentleman, there was a crater produced in the carbon by an alternating current. When they had had a direct current the crater in one carbon would be very much larger than in the other. It was very evident that when they placed two carbons in that way the best of their light was lost—locked up in the craters; and even with a single crater with a direct current there must be at all times a great loss of light, because the positive carbon must cover it to a very great extent. He had been making experiments with carbons fluted, for which he thought there was a great future. By using fluted carbon they abolished the carbon altogether, which was a very important point. He had a model (shown) of a carbon that had been at work with an arc of 30,000 candles. The walls of the crater were completely eaten or licked away by the attack which was made upon the crater in the flutes. Then, again (and this was another very important point referred to just now), they had the arc held centrally in the carbon. That for lighthouse illumination was a very important matter. Any departure from the central position of the carbon affected the flashes, sometimes affecting their duration. A flash might begin too soon or end too late, or it might be too prolonged. When prolonged it was considerably weaker, and, consequently, the flash might be entirely lost from want of intensity. Then, again, nothing to his mind could be more perfect than the luminary formed by a pair of the best carbons. They had in that case a luminary which was perfect as regarded its compactness, perfectly central, and with large increase of radiance vertically by the light which passed between the flutes above and below compared with the solid carbon. They found also that the carbon was cooler. The heat was localised at a point, which was so much the better for the lamp.

Mr. WIGHAM said that as the President had mentioned his (the speaker's) name in connection with his address, he thought it was right that the audience should know that it had been his desire that all the illuminants should have been tried at their very best and under all circumstances.

The PRESIDENT then moved a vote of thanks to Dr. Hopkinson, which was cordially passed, and the proceedings terminated.

COMPANIES' MEETINGS & REPORTS.

Eastern Extension, Australasia, and China Telegraph Company (Limited).

The twenty-sixth ordinary general meeting of this Company was held on Wednesday, at Winchester House, 50, Old Broad-street.

The chair was occupied by John Pender, Esq.

The SECRETARY (Mr. F. E. Hesse) read the notice convening the meeting, and the minutes of the last meeting, which were confirmed by the present meeting, and signed by the Chairman as correct.

The CHAIRMAN: I presume you will take the report as read. I will, as usual, before asking you to approve of the report, make some few remarks and give some figures as to the working of the Company in the last six months. The gross receipts for the half year have amounted to £224,843, against £259,476 for the corresponding period of 1885, showing a decrease of £34,633. This loss of revenue is in some measure attributable to the general depression of trade, but it is chiefly owing to the absence of any stirring incidents, such as those which were of continual occurrence last year, and which, if you remember, I referred to very fully in the speech which I made six months ago. This will be understood when it is mentioned that in the six months ending June, 1885, public interest was excited by the Egyptian campaign, to which New South Wales sent a contingent; the Penjdeh incident in Afghanistan; and the hostilities between China and France, arising out of the annexation of Tonquin. All these events caused a considerable exchange of telegrams, by which we, as well as other telegraph administrations, largely benefited. Our revenue was never so large as during the sitting of the Berlin Conference, to which, as you are aware, this Company was invited to send representatives. We were urged on all sides to lower our tariffs, which were alleged to be prohibitive, and, although we did not see our way to reduce them to the extent desired, we partly yielded to the wishes of the Australian representatives, encouraged by the growth of traffic, which, as regards Australia, had for some years past shown an annual increase of over 10 per cent. It is a singular circumstance that within a few months after the Conference, when we were committed to make some reductions of tariff, the traffic began to show some signs of falling off, which has continued ever since. The decrease for the half year under review is spread over the whole

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of our system, as will be seen from the figures I will mention. This may appear a rather gloomy view of the question, but, as I have often said on all these occasions, telegraphy is greatly influenced by trade, and, as we observe, there is a very great change going on now in trade. Even in the City they are talking of "booms," and I expect we shall begin to feel that excitement before long. In the six months under review our income from Australasia shows a reduction of £13,000; from Java, £2,500; from Tonquin, Cochin China, and Siam, £5,200; from China and Japan, £5,000; from local traffic, £2,200; from the New Zealand subsidy, £2,700, and lost by exchange £4,000. That is the silver question, which is engaging a very great deal of attention at the present time. All these sums amount to £34,600. They are together a large sum at present; but there is nothing in them that may not be materially altered when I have the pleasure—if I have the pleasure—of addressing you six months hence. Unfortunately, since the close of the half-year, the traffic has shown a proportionately larger decrease than in the first six months, amounting to £30,000 for the three months ending September, against a loss of £34,000 in the previous six months. Only a portion of this amount is attributable to the reductions of tariff which came into force on the 1st July, there being, except in the case of Australia and Java, an actual falling off in the number of messages, and this diminution of traffic was unfortunately aggravated by our misfortune last month, when both of our India-Penang cables were simultaneously interrupted for the first time since this portion of our system was duplicated nine years ago. I am pleased to remark that as far as Australia is concerned, there was in the last quarter a small increase in the number of words transmitted over the corresponding three months of 1885, which slightly lessened the loss occasioned by the reduction of tariff; but in regard to China, Tonquin, and Cochin China, we have not only to bear the loss resulting from the reduction of tariff, but also the loss arising from the falling off in the traffic. The working expenses for the half year have amounted to £81,775, against £74,418 for the corresponding period of 1885, showing an increase of £7,357. This increase is practically accounted for by our having had an additional maintenance ship, as compared with the corresponding period of 1885. This expense will, however, be saved for the current half year, the ss. "Agnes" having been sold at public auction in July last. The usual interim dividends at the rate of 5 per cent. per annum have been paid for the half year, but in consequence of the decrease of revenue already referred to, your Directors considered it prudent not to pay any bonus, but to carry forward the whole balance of £34,980 to the current half year. If the figures during the current half year admit of a bonus being distributed, it can be dealt with at the end of the year—that is six months hence. In fact, when we first established the principle of bonuses we agreed that the bonus should be paid at the end of the year, but some of the shareholders were anxious to get the benefit of it at the end of the first six months, and expressed a wish to the Directors to that effect, and said that the money would be better in their pockets than lying at the bank, and therefore we agreed to give them the bonus half yearly, being perfectly satisfied that it was earned. I hope there will be a better state of things next half year, and if the figures warrant the payment of a bonus it will be dealt with at the end of the financial year. It will be seen from the printed report that the policy of strengthening the Company's system has been continued by the renewal in June last of the Singapore-Penang (original) cable. A considerable portion of the old line was recovered, and when overhauled and repaired, will be taken into the Company's stock of spare cable at Singapore for future extensions or renewals. The cost of the operation will be dealt with in the current half year's accounts. I have on various occasions referred to those cables and the principle upon which we are renewing them. I have always told you that we have had to contend against an insect, the teredo, which is very destructive, and that the injury thus done to the cables was such that we thought it better to meet the difficulty at once, and lay down brass sheathed cables so as to prevent anything like damage or interruption from the teredo. We have done this successfully, and, so far, since we have used this precaution, we have had no fault from the teredo. The maintenance ships have been kept busily employed during the greater part of the half year in effecting numerous repairs, but no interruptions of importance occurred to the traffic until after the close of the six months under review, when both our India-Penang cables were interrupted, as already stated. Fortunately, however, they were both repaired after thirteen days total interruption, notwithstanding the south-west monsoon prevailing at the time. All the cables are now working well. Our relations in regard to the China system, I am glad to say, have been materially strengthened since I addressed you six months ago. I went over to Copenhagen to meet the Directors of the Great Northern Company, with whom we work this system. There were difficulties and sores which had existed for a considerable time. These were not likely to be removed by correspondence. The result of my visit was that we placed our relations with the Great Northern Company on a most satisfactory footing. Those relations will continue for a very long period of time, and, so far as I can judge, will be very beneficial to both companies, and, I think, lead to considerable economies in the working of the two systems. We are going to work at Shanghai under the same roof, and also at Hong Kong. The effect will be economy, and, I believe, efficiency. We have gone into this question with a minuteness that ought to insure stability in the working of the system. We had with us a representative from China of our system, and a representative from China of the Great Northern system, and, putting all our heads together, I believe we have made such an arrangement as ought to be very satisfactory, and very beneficial to all concerned. The next question I have to deal with, and which I referred to at the last meeting, is the negotiation that has been going on with the New Zealand Government. Nearly nine months ago, the subsidy of £7,500 per annum which we received from the New Zealand and New South Wales Governments came to an end. I made proposals for renewing it. The New South Wales Government were quite prepared to renew it for 10 years, but the New Zealand Government objected to renew it for that period, but agreed to a renewal for five years. We did not consider that the five years' renewal was sufficiently beneficial to us, because we had found during the whole of 10 years that the return from the cable did not give us, after calculating amortisation, more than 2 per cent. on the capital invested. I therefore held that we were entitled to have the subsidy renewed for the full period. However, after some negotiations, and the Parliament having decided on the five years, we reconsidered the question, and, looking at it in connection with the larger questions which we hope to see carried out eventually in the Australasian colonies, we agreed to accept the five years. Negotiations then went on again with the Postmaster-General of New Zealand, Sir Julius Vogel—a gentleman very well known in London and all over the colony, when at the head of the Government, and it was with him that I conducted these negotiations. After trying in every possible way to conciliate the New Zealand Government, and to get them to renew for five years, we have been driven into this position—that they have declined the five years, and they have declined arbitration; and the reason given for this is that they think that any subsidy would interfere with the laying of an opposition cable between Australia and Europe *vid* the Pacific. Now, it is well that you should know the whole of the facts. There is no immediate possibility—I do not think that there is any possibility—of a cable being laid in opposition to our cable, for the simple reason that I do not suppose that the colonies at the present moment, but particularly New Zealand, have too much money to throw away. I do not think this would be approved, and I doubt if the people of New Zealand would approve of the spending of money on an opposition cable when they can get from the present Company a cheaper and more efficient system of telegraphy than can possibly be procured by another cable. I make this statement advisedly, and I wish it to go before the public by the press taking full notice of it. I will give you figures which will bear out my statement. Taking the figures of the proposed opposition, and taking the subsidy which they would require to cover expenses and obtain 5 per cent. on their share capital as compared with the cost of our guarantee proposal, calculated on the same basis and giving precisely the same tariff, the cost to the Colonies apart from any subsidy that might be obtained from Canada would be as follows:—

Colony.	Subsidy for Pacific Scheme.	Guarantee for Existing Companies.
Victoria	£35,680	£16,353
New South Wales	34,194	15,672
South Australia	11,610	5,321
Western Australia	1,223	560
New Zealand	20,945	9,599
Queensland	21,503	5,274
Tasmania	4,845	2,221

I think you will agree with me that no body of sensible men, either at home or in the colonies, would be justified in subsidising a company with a single line of cables in opposition to an existing one doing the work so well as we are doing it—with a duplicate system. I therefore have no fear of any opposition coming if it is dependent on receiving a subsidy from the British or Australasian colonies. I will go a little further than that. If, instead of subsidising an opposition company, they will give us the subsidy which the opposition company desires to get, that is £100,000 a year, we will give them a tariff of 2s. 6d. instead of 4s, the tariff which the opposition proposes to give. That would be an extraordinary revolution, to have a message carried to Australia on such a tariff as 2s. 6d. We are prepared to do it if they will give us the terms the opposition company want, and without obtaining which it could not cover expenses, and even then the tariff would be 4s. I speak from practical experience of a great many years of submarine telegraphy. Gentlemen who try to get up opposition companies frequently know nothing about telegraph working, but if they can get millions sterling to manipulate, they expect a considerable amount may be shared between them in the form of promotion money. Your Company has not been established in that manner, but upon fair and sound principles, and by sound principles we are determined to stand. I think we can meet all competition, come from what quarter it may, if it is dependent on subsidy from the Governments of Australia, New Zealand, and England. I think I have shown you pretty clearly how we stand at the present moment. I will say one word more in regard to the correspondence which has taken place in regard to the New Zealand cable negotiation. I have told you that we have exerted every possible means of bringing about a conciliatory arrangement. We have got with us—which was not always the case—the Press of New South Wales and the Press of Victoria. I believe I may say that the Governments of those two great colonies also approve the position we have taken up. When we offered to refer the case to arbitration, we thought it was not possible that Sir Julius Vogel could decline the proposal. He has, however, this morning, after a week's delay, refused arbitration. He does not see that there is any necessity for it. Now, gentlemen, on Monday next we shall put up our rates between Sydney and New Zealand from 6s. to 10s. per ten words for Intercolonial telegrams (hear, hear), and we shall show them that private enterprise, having done so much for the colony, is not to be trodden down in the way which they have attempted. Nay, more than that. Our bargain with New Zealand was that even after the termination of the subsidy they were bound to give us the same accommodation for the following ten years, whether the tariff was raised or not. They now threaten to take away that accommodation. If they do we shall shut the door and lock it till they give us the amount that will enable us to carry on the traffic with a fair profit. I think you will approve of that policy [applause]. I am perfectly satisfied that if you do the public of Australia and of

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New Zealand will not tolerate a suspension of traffic for one week, but will force Sir Julius Vogel's hand, if it does not force him from power. I am sure you will give us your approval of putting up the tariffs, and they will remain up until we get such a satisfactory arrangement as a company of this importance, dealing with such interests, is entitled to at the hands not only of New Zealand but from every Government in Europe. We have had that consideration, and we shall insist on maintaining the dignity and position of this Company by not being trodden on by the Government of New Zealand. Gentlemen, I have spoken strongly and warmly, but I think it just as well that these remarks should go abroad strengthened by the approval of the shareholders whom I am now addressing. With these remarks I beg to move, "That the report and accounts now submitted be received and adopted."

The Most Hon. the Marquis of TWEEDDALE seconded the motion.

A short discussion ensued, during which Mr. GUESDON deprecated the practice of sending out proxies unless in blank and unstamped, and called attention to the increased working expenses in recent years, and urged economies; and Mr. GRIFFITH warmly supported the policy of the Board, whereupon

The CHAIRMAN said: I have heard Mr. Guesdon speak on the same subject for a good many years. He is one of those whom I call economical reformers; but I am always glad to hear his side of the question. I am bound, however, to say that I cannot in the least degree agree with him. In the first place I will deal with the question of proxies I may tell you that we are perfectly aware of the decision of Mr. Justice Kay on the question of proxies; and the proxies that have been sent out have not been at your expense. The Directors have sent them out at their own expense. Now let me say one word for proxies. We wish to act legally, but also fairly, to the large body of shareholders. We have nearly 5,000 shareholders, and there are not more than 100 here to-day. Is it right or fair that the absent 4,900 shareholders should be left entirely to be dealt with by the 100 who are present? I may say, further, that there is one-fifth of the shareholders in Ireland, and it is not always convenient for them to take such a long journey to attend our meetings. I think, as has been often explained at these meetings, that the least that shareholders having confidence in the Directors can do is to give them, at an unfortunate time like this, their proxies if they cannot be present themselves. I should like it very much better if all our shareholders were present, as then our policy could be fairly judged, and they would consider what was best for their own interests and vote accordingly; but I cannot see the justice of letting 100 shareholders control the affairs of 4,900. The decision the other day might have been just. I daresay it was, or it would not have been given by one of our eminent judges, and therefore we, acting in the interests of the large body of shareholders, preferred to pay ourselves for proxies rather than that their interests should be for one moment jeopardised. That is my view of the proxies. Now, in regard to economies which Mr. Guesdon has suggested, he forgets that this Company has become a company of very great magnitude indeed. He cannot have followed its growth if he thinks that the same number of clerks and the same amount of accommodation are sufficient for the Company to-day, as when it was first introduced before the public. We have grown "by leaps and bounds," we have paid you high dividends. We have been obliged to open stations in almost every part of the world where civilisation and commerce exist. We have followed the flag everywhere, and do you expect that that can be done without a large extension of expenditure? We have increased our income at the same time, though I have told you to-day that we are just now passing through a crisis of depression. We cannot be exempt from the existing depression any more than other institutions. We live by trade, and, as I have frequently said on these occasions, there are cycles of good and cycles of bad times. Curiously enough, we have grown under all these cycles, and although we have lately had depression, I see even now a return of better times. We have made this Company great and prosperous, because we have acted liberally and justly in the conduct of your affairs. If you are to bind us down to what I call a small way of conducting your affairs, I am afraid we shall not be able to show you anything like the results we have been able to show you in the past.

The CHAIRMAN then put the motion to the meeting, which was unanimously carried.

Mr. GIBB: I wish to propose a vote of thanks to the Chairman and Directors for their services. I think that no one can have been here to-day without seeing the zeal and ability with which our affairs are conducted.

Mr. VARLEY: I have great pleasure in seconding the motion.

The resolution was then put to the meeting and carried unanimously.

The CHAIRMAN: I am very much obliged to you, gentlemen. We are always watching your interests closely. There was some remark made about the attendance of the Directors. I assure you that it is not only your Board meetings that you must think of. There are attendances by some of us at every hour of the day. For myself, for instance, there are very few days on which I am absent from the office. As long as we are here, we will maintain the dignity as well as the financial position of this Company to the utmost of our power.

The proceedings then terminated.

Brazilian Submarine Telegraph Company.

Report and accounts of the Directors for the half year ended 30th June last, to be submitted to the twenty-sixth ordinary general meeting of shareholders, to be held at Winchester House, 50, Old Broad-street, E.C., on Thursday, 4th November, at two o'clock.

The revenue for this period amounted to £75,856. 10s. 10d., and the working expenses to £12,695. 5s. 4d. After providing £9,680 for debenture interest and sinking fund, and £1,430. 7s. 4d. for income tax, there remains a balance of £52,050. 18s. 2d. To this is added £2,123. 16s. 4d. brought forward from 31st December last, making a total of £54,174. 14s. 6d. A quarterly interim dividend amounting to £19,500 has been paid, and £13,000 transferred to the reserve fund, leaving a balance of £21,674. 14s. 6d. The Directors now recommend the declaration of a final dividend of 3s. per share, making, with the interim dividends, a total payment of 6 per cent. for the year ended 30th June, 1886, and that the balance, £2,174. 14s. 6d., be carried forward to the next account. Since the last general meeting the African Direct Telegraph Company have completed their system of cables between this Company's station at St. Vincent and the British possessions on the West Coast of Africa, viz.:—Bathurst, Sierra Leone, Accra, Lagos, Brass, and Bonny. The traffic from these lines will pass over this Company's cables between St. Vincent and Lisbon. The subscription by this Company of £75,000, being one-third of the share capital of the African Direct Telegraph Company, authorised by the extraordinary general meeting held 21st January last, has been effected by a second issue of 5 per cent. debentures, at the price of £105 per £100. The various sections of the Company's line are in good working order. Senor Carlos Frederico Taylor and Mr. Frederick Youle retire by rotation at this meeting, and being eligible for re-election as Directors, offer themselves accordingly. The two auditors, Mr. Henry Dever and Mr. John Gane, also offer themselves for re-election.

BUSINESS NOTE.—In consequence of a misunderstanding which appears to prevail among the trade, Messrs. Goolden and Trotter ask us to state that while the foreign agency of their dioptric glass (Trotter's patent) is in the hands of Messrs. Woodhouse and Rawson, the English trade remains in their own hands as heretofore; there being no sole agency for Great Britain.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. OCT. 27.		BUSINESS DONE WEEK ENDING OCT. 27. Highest.		Lowest.	
Anglo-American	40,	41	.....	41⅜	.....	38⅞
Do. Preferred	62½,	63½	.....	65	.....	60⅝
Do. Deferred	17,	18	.....	18½	.....	13⅜
Brazilian Submarine	10⅞,	11⅛	.....	11⅛	.....	10 15-16
Cuba	11⅛,	11⅜	.....	11⅜	.....	11⅛
Do. Preference	18,	19	.....	—	.....	—
Direct Spanish	1½,	2	.....	—	.....	—
Do. Preference	8½,	9½	.....	—	.....	—
Direct United States Cable	9⅜,	9⅝	.....	9⅝	.....	9⅜
Eastern Telegraph	10⅜,	10⅝	.....	10⅝	.....	10½
Do. 6 per Cent. Preference	14½,	14¾	.....	14⅜	.....	—
Do. 5 per Cent. Debentures, 1899	105,	108	.....	—	.....	—
Eastern Extension	10⅞,	11⅛	.....	11⅛	.....	10 15-16
German Union	9½,	10	.....	—	.....	—
Globe Telegraph and Trust	6,	6½	.....	6 5-16	.....	6 1-16
Do. Preference	12½,	13	.....	13½	.....	12 15-16
Great Northern	13½,	13½	.....	13⅜	.....	—
Indo-European	35,	36	.....	36	.....	35½
Reuter's	7½,	7¾	.....	7½	.....	—
Submarine	195,	205	.....	202	.....	195
West India and Panama	⅜,	⅝	.....	⅜	.....	—
Do. 1st Preference	8,	8½	.....	8½	.....	8 7-16
Western Brazilian	6⅜,	6⅝	.....	—	.....	—
Western Union 7 per Cent. 1st Mortgage	118,	122	.....	—	.....	—
Do. 6 per Cent. Sterling Bonds	101,	103	.....	—	.....	—

TELEPHONES.

Consolid. Telephone and Maintenance	13-16	15-16	.....	⅞	.....	—
Oriental	3-16	5-16	.....	—	.....	—
United Telephone	14½,	14½	.....	14⅝	.....	14⅜

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	2¾,	3¼	.....	2⅞	.....	—
Do. (fully paid)	4½,	5	.....	—	.....	—
Swan	1⅜,	1⅝	.....	1 7-16	.....	—
Maxim Weston	¼,	⅜	.....	—	.....	—

MISCELLANEOUS.

Telegraph Construction	39	40	.....	40	.....	39½
India Rubber, Gutta Percha, and Telegraph Works	24	25	.....	24⅞	.....	24½

TRAFFIC RECEIPTS FOR SEPTEMBER, 1886.

COMPANIES.	Sept., 1886.	Sept., 1885.	Increase.	Decrease.
Cuba Submarine	2,250	2,160	90	—
Direct Spanish Telegraph	1,751	1,793	—	42
Eastern Extension	30,107	41,845	—	11,738
Eastern Telegraph	40,778	47,849	—	7,071
Great Northern	25,600	—	—	—
West Coast of America	3,585	—	—	—

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NOTES.

ELECTRIC RAILWAY IN BAVARIA.—An electric railway has been opened for public use at Schwabrig, Bavaria.

BOOKS RECEIVED.—From Messrs. Iliffe and Sons we have received a copy of "Practical Dynamo Building for Amateurs," by F. W. Walker.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 29th ult. amounted to £4,104.

THE WEST COAST OF AMERICA TELEGRAPH COMPANY.—The gross earnings of this company for the month ended Oct. 31st were £4,825.

LUBECK.—The Municipality of Lubeck has voted the sum of £17,000 for the establishment of a central electric lighting station to supply both arc and incandescent lamps.

EASTERN TELEGRAPH COMPANY.—The traffic receipts of this company for the month of October amounted to £49,374, and to £56,994 in the corresponding period of 1885.

DARKEHMEN.—The village of Darkehmen, in the Western Prussia, has been lit by electricity, the motive power for which is furnished by turbines on the River Angeraph.

DIRECT SPANISH TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the month of October, amounted to £2,013, against £1,756 in the corresponding period of last year.

PERSONAL.—We understand that Messrs. Bernard Drake and J. M. Gorham have left the service of the Electric Power Storage Company, and will shortly establish themselves as consulting electricians.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended the 31st Oct. are £2,091, as compared with £1,942 in the corresponding period of 1885.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY.—The traffic receipts of this company for the month of October amounted to £37,185, and to £43,986 in the corresponding period of 1885.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 29th ult. were £3,307, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

THUNDERSTORMS IN BAVARIA.—The number of severe thunderstorms in Bavaria has this summer been unprecedentedly large. No less than 591 instances of personal or material damage from lightning are reported for the three months ending in June last.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic returns of this company for October were £22,240, and the receipts for the period from 1st January to 31st October, £217,800; for the corresponding months in 1885 and 1884, £241,640 and £234,680 respectively.

THE TELEPHONE IN RUSSIA.—It appears that up to the present time about 10,670 kilometres of telephone lines have been erected in Russia, of which about 4,000 kilometres are in St. Petersburg and about 3,000 in Moscow. The number of instruments in use is not stated.

INTERRUPTION OF CABLES.—The cables between St. Vincent and Grenada, and between Dominica and Martinique are interrupted; and there is, therefore, at present no telegraphic communication with the Islands of Martinique, St. Lucia, St. Vincent, and Barbadoes.

GUTTA PERCHA MOULDS FOR ELECTROTYPES.—According to the *Organe Industriel* gutta percha moulds for electrotype reproductions can be advantageously made from a hot saturated solution of the rubber in linseed oil. This solution sets hard on cooling, and the mould is then treated in the usual way.

ELECTRIC LIGHT AT A CONCERT.—A smoking concert was held on Saturday last, by the Lewisham Bicycle Club, to celebrate the last run of the season. The building was illuminated with incandescent lamps, supplied with current from accumulators from the works of Messrs. Arthur B. Gill and Co., electrical engineers.

THE SOCIETY OF TELEGRAPH-ENGINEERS.—The next meeting of this society will be held at the Institution of Civil Engineers, 25, Great George-street, S.W., on Thursday, 11th Nov., at 8 p.m., when a paper will be read upon "The Predetermination of the Characteristics of a Dynamo," by Gisbert Kapp, associate.

THE ESTIENNE TELEGRAPH.—We recently notified the fact that the French Telegraph Administration had determined to adopt the Estienne system upon an extensive scale. We now learn that the results of the experience of the last few weeks are deemed highly satisfactory, considering the comparative inexperience of the operatives.

THE CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this company during the month of October was 2,783, estimated to produce £2,400, against 2,694 messages, producing £2,156 in the corresponding month of last year. The traffic receipts for the month of July, estimated at £2,800, realised £2,818.

THE EXPECTED RIOTS.—It is said that on Lord Mayor's Day the whole of the principal police-stations of the metropolis will be in telephonic and telegraphic communication, so that the reserves may at once be despatched to any point where their presence is required. The Post Office Volunteers will on this occasion form part of the Lord Mayor's procession.

AN ELECTRIC TOY.—We have received from M. E. Reynaud, of 58, Rue Rodier, Paris, an illustrated description of an ingenious electric toy which he calls "praxinoscope théâtre électrique." The performances of the puppets on the mimic stage proceed automatically by the help of an electro motor and battery, and the whole is illuminated by electric light.

"THE REPETITION CODE."—We have received a copy of "The Repetition Code," designed to economise the time and labour necessary to obtain the repetition of doubtful words in foreign telegrams, arranged by the managing director of the Eastern Telegraph Company, and by the superintendent of the company's London stations. This book is printed at the office of *The Electrician*, 1, Salisbury-court, E.C., and is published by subscription only.

TENDERS ASKED FOR.—The Cheshire Lines Committee invite tenders for the supply during the year 1887, among other things, of telegraph materials and instruments, galvanised iron, and copper wire. Patterns can be seen, and specifications, with forms of tender, obtained, on and after 8th November upon application to Mr. W. H. Legge, storekeeper, Cheshire Lines, Warrington. Tenders to be sent in by 10 a.m. on 3rd December to Mr. E. Ross, secretary, London-road Station, Manchester.

MALICIOUSLY CUTTING A NEWS WIRE.—At the Worship-street police-court on Friday last a man named A. Saunders, of 52, Upper-street, Islington, was charged with having

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maliciously cut wires belonging to the Exchange Telegraph Company, in Bethnal Green-road, in order to delay news. At the request of the prosecution the matter was dealt with by the magistrate, and the prisoner, who had rendered himself liable to two years' imprisonment, was sentenced to three months, with hard labour.

INSTALLATION AT POOLE.—Messrs. G. and T. Belber, millers, of Poole, Dorset, have recently had their premises fitted up throughout with electric light. The installation has been carried out by Mr. Wilson Hartnell, of Leeds, and consists of 104 Edison-Swan lamps, of 16 candle-power, supplied with current by a No. 4 Crompton compound-wound dynamo, running at a speed of 1,000 revolutions per minute. A Turner vertical engine is used, for which steam is supplied by the boilers belonging to the mill engines. Hartnell's patent three-circuit switch-boards are used.

TESTING THE STRUCTURE OF LAMP FILAMENTS.—Mr. Weston has devised the following simple and ingenious method for examining the filaments of glow lamps for structural defects. The lamp is mounted upon a whirling table, and connections are made with suitable mercury contacts. When a current is sent through the lamp while very rapid rotation is imparted, any part of the filament which has a higher resistance appears as an excessively brilliant band of light. In this way it becomes possible with practice to form a good idea as to the probable length of life of the lamp.

HOME NEWS FROM ABROAD.—We learn from a Transatlantic contemporary that the City of London now contains the second largest Edison Central Station in the whole world, New York coming first, and Milan third. The London station is said, moreover, to contain the largest Edison dynamos yet constructed. We are not told how many machines are employed, but they have each a capacity for 12,000 lamps. We are very pleased to hear this, on the authority of one of the leading technical journals of the States; but the affair has hitherto been kept uncommonly dark over here.

THE TELEPHONE ON GERMAN RAILWAYS.—From a report recently issued we gather that the telephone has come into extensive use upon the German railways. No less than 33 companies have given it a trial; the results are, as a whole, satisfactory, but it has not been found practicable to rely entirely upon the telephone for signalling service, except upon lines where the traffic is very slight. On busier lines the telephone has proved to be a valuable supplement to the telegraph equipment, and in the large stations it is extensively used to connect the various offices and departments. Altogether nearly 30,000 kilometres of telephone wire have been erected upon the German railways.

THE ELECTRIC LIGHT IN MADRID.—At a meeting of the Madrid Mercantile Club, held on the 24th ult., it was determined to proceed with the scheme for establishing a large central electric light station. Some details of this scheme we gave last week. A company is to be incorporated forthwith, under the title of the *Union Mercantil é Industrial de Alumtrado Electrico*. It was stated that two foreign companies were prepared to contract for the supply under the stipulated conditions (the principal of which is that the cost should not exceed three centimos per hour per 10 candle-power lamp) but only upon the further understanding that the guaranteed minimum consumption shall not be less than the equivalent of 6,000 lamps "per day" (of how many hours does not appear). It was also mentioned that a third company would be willing to undertake the work at the price of one centimo per 10 candle-power lamp per hour.

EVENING UNIVERSITY LECTURES ON IRON AND STEEL.—A course of eight lectures on this important subject has just been commenced at King's College, by the Demonstrator of Metallurgy, Mr. W. G. McMillan, F.C.S. These lectures will be delivered on Tuesday evenings, from 7 to 8, and it is proposed in them to treat of the general methods by which the different qualities of malleable iron, cast iron, and steel may be produced and prepared for use in the arts; of the effect of the various foreign substances contained in these metals upon their strength and fitness for the purposes to which they are to be applied; of the extent to which these substances are injurious, and the means by which they are commonly eliminated. There can be no question that an acquaintance with the metallurgy of iron must be of great value to all electricians who are in any way concerned with the manufacture of dynamo-electric machinery.

A NEW HEAT BATTERY.—Signor V. Riatti has constructed a somewhat novel arrangement for effecting the direct conversion of heat into electricity. He takes a rectangular vessel tall in proportion to its sectional area. Two copper tubes are passed through the sides of the vessel, one near the top and one near the bottom; these tubes pass through from side to side without opening into the vessel itself. The latter is then filled with a solution of sulphate of copper, and a current of cold water is passed through the lower tube, while superheated steam under a pressure of several atmospheres passes through the upper tube. Under these circumstances on closing the circuit with the two tubes as electrodes a current is obtained which passes externally from the cold to the hot tube, while copper is dissolved from the upper and deposited on the lower tube The battery is described as being "economical and easy to maintain," but it is not very clear how it can be expected to receive any commercial application, except possibly in large telegraph offices. Compared with Mr. Case's heat cell it labours under the disadvantage of not being reversible, as it would scarcely do to heat the lower tube.

THE ELECTRIC LIGHT AT GREENLANDS. — The following paragraph recently appeared in *The Times*:—"The country seat of the Right Hon. W. H. Smith, M P., at Greenlands, has recently been lighted by electricity. The installation is very complete, and consists of nearly 250 Swan glow lamps. The current is conducted by underground wires from the engine house, which is about 200 yards from the mansion. The generating machinery consists of a locomotive boiler and a Paxman 12 horse-power compound engine, driving two Crompton dynamos, each capable of supplying the current to 200 glow lamps, and regulated by a Willans automatic electrical governor, which maintains a constant electromotive force at all times, thus insuring perfect steadiness in the lights. In order to save running the machinery on Sundays, or at other times when the full number of lamps is not required, a battery of accumulators is used. The wires are all laid in wood casing painted with three coats of asbestos paint, and every precaution against fire has been taken." Messrs. Crompton and Co. inform us that the dynamos supplied for this installation have realised, on testing, a commercial efficiency of 90 per cent; and also that the accumulators supplied are able to maintain the full current for three days' running, while the period required for charging has been reduced to such an extent that the actual personal attendance required will not exceed two half-days per week.

THE LIGHT OF OTHER DAYS.—A letter appears in the *Pall Mall Gazette*, setting forth the views of one who describes himself as having encountered a heavy blow, on making the discovery that the electric light had been placed in the Temple Church. "No more gathering shadows in the beautiful roof,

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no more golden candle lights, shining like jewels" in the sepulchural gloom. "In the one place where London fog and gloom and darkness were apotheosized, they are expelled for ever." This is sad indeed. Yet we do find people here and there who would be prepared to back a glow lamp for "shining like a jewel" against any farthing rush-light. There are others who would prefer a stage-coach to a Pullman express, flint and steel perhaps to a lucifer match, and tallow to electricity. In our issue of the 25th June last we referred at some length to the electric lighting of the Temple Church, which was carried out by Messrs. Mortimer, Shepherd and Co., of 2, Great Queen-street, on the occasion. of the visit of the Princess Louise. This installation although intended to have been merely of a temporary character, has ever since remained in use. Several experimental alterations have been made in the grouping of the lamps, and the arrangement adopted at present consists of three light wrought-iron chandeliers suspended from the centres of the arches in the round tower, and a single light at each of the four corners of the capitals of the columns in the nave. The installation has received unqualified praise, and from the æsthetic point of view the effect has hitherto been the subject of general admiration.

"COFFERDAM."—The name of "cofferdam" has been given to a curious substance, a preparation of cellulose, which has recently been obtained by a young French chemist, M. P. Germain. Its uses in connection with electricity have been investigated by M. André Regnier, the electrician to the Société Générale des Téléphones. From a report which has been written by M. Reynier for *L'Electricien* we gather that "cofferdam," or "sporique," as its finer variety is termed, is prepared from the husks of the cocoa-nut; it has the colour and aspect of cocoa powder. The extraordinary properties of this substance arise from its extreme lightness, its specific gravity being represented by the abnormally low figure of 0·08. Under the simple pressure of the hand its volume can easily be reduced to one-third, and even then its density is only about one-fourth that of good sponge. Its absorbing power surpasses that of all other known materials. A given volume of cofferdam can easily be made to take up a volume of liquid equal to itself, without any perceptible increase in the total volume; or, in other words, the volume occupied by the cofferdam in the combination is *negligible*. A good sponge will absorb seven times its own weight of water, cofferdam absorbs 12·5 times its weight of water. The substance has hitherto been found to be insoluble both in acids and in alkalis and in solutions of salts. It is therefore evident that it will thus readily lend itself for use in primary or secondary batteries. M. Reynier states that the resistance of the battery is not perceptibly increased by its presence, and it is suggested that by saturating two separate slabs of the substance it may be employed in two fluid batteries, thus doing away with the porous cell. Not only are the liquids thus kept separated and preserved from accidental spilling, but it is also found that the loss from evaporation proceeds much more slowly. It would appear that the substance is certainly worth a trial for the purpose indicated.

SHIP LIGHTING BY ELECTRICITY.—Last week the official trial of the electric installation on board the Indian troopship "Dalhousie" took place on the voyage between Greenock and Birkenhead. The installation consisted of 168 Edison-Swan lamps of 20 candle-power, and 16 lamps of 50 candle-power arranged in two yard arm reflectors. The dynamos were two Goolden-Trotter A type, driven direct by Willans three-cylinder compound tandem engines at 300 revolutions, each capable of maintaining the entire number of lights. The engines were started on the full installation at 10 a.m. on Thursday morning, and ran without intermission for fifty-four hours at full load, the vessel being at sea during the last twenty-four hours of the run. The engines and dynamos ran faultlessly while in harbour, but the value of the test at sea was shown by the detection of a defective arrangement of the connection of the steam pipes with the boiler, which allowed water to reach the engines when the vessel was under weigh, and at times gave some trouble. So far as the electrical details were concerned, however, the lighting was a pronounced success, and when the fault in the steam connection is remedied the installation will be perfect. We are informed by the contractors that the lamps gave a light of 20 candles at 80 volts, though marked 16 candle-power, taking an average of 73 watts, thus showing an actual efficiency of 3·4 watts per candle, and nominally of 4·45 watts per candle. It is, however, a doubtful economy to run lamps at 25 per cent. above their nominal capacity. Mr. Jopp, Director-General of Stores, inspected the installation on the arrival of the vessel at Birkenhead. The work was carried out by the firm of Goolden and Trotter, of Westminster, the ship being fitted on Admiralty specification, under the supervision of Mr. Scott, their superintending engineer. The "Dalhousie" and "Lawrence" were finished together in 12 weeks from the commencement. Both ships sail for India this week, and are the first vessels of the Indian marine which have been fitted with the electric light.

OVERHEAD TELEGRAPH AND TELEPHONE WIRES.—At the meeting of the Metropolitan Board of Works, on Friday last, a report was presented from the Works and General Purposes Committee on the subject of overhead telegraph and telephone wires. The committee stated that they had proceeded upon the resolution of the Board of the 8th January, referring it to them to inquire into the recent accidents by overhead telegraph and telephone wires, and the danger to the public arising therefrom; and as to the necessity of any proceedings or future legislation on the subject. The committee had also had before them the several communications which had been referred to them by the Board from vestries and district boards of the metropolis with reference to this question. The Board were aware that the House of Commons last year appointed a select committee to consider the law relating to the control of over telegraph, telephone, and other wires. From their report, which was made to the House on the 12th of May, it appeared that the committee had come to the conclusion that the risk of danger to the public from overhead wires had been exaggerated, but at the same time they were of opinion that the probable development of the telephonic system made it desirable that there should be some change in the law with a view to the better supervision of the wires. The committee, after carefully considering the reference, and having, as directed by the Board, obtained from the surveyors to the several vestries and district boards information as to damage which had resulted from the breakage of wires within their districts, concurred in the opinion expressed by the Select Commitee that better supervision is desirable, and submitted the following resolution:—"That a communication be addressed to her Majesty's Government calling attention to the danger likely to arise from the increasing number of overhead telegraph and telephone wires, and suggesting that such wires should be placed under proper supervision, as recommended by the Select Committee of the House of Commons in the year 1885."—Mr. Edwards, without comment, moved the adoption of the report and resolution, which was agreed to.

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THE LIGHTING OF THE BARTHOLDI STATUE.—The New York Correspondent of the *Daily News* telegraphs:—The Bartholdi statue was illuminated by the electric light for the first time on Monday night, being the first pleasant evening since the unveiling. The torch was lighted by nine arc lights arranged in two horizontal circles, one inside the other. Each light is placed midway between and opposite two horizontal rows of glass lenses set in the face of the torch to illuminate the outer surface of the statue itself. There are five 8,000 candle-power electric lights in five of the salient angles of the fortifications surrounding the statue. Behind each light is a cylindrical parabolic reflector, by which the light is focussed on the pedestal and statue. Each light is four times as powerful as an ordinary arc light. Four lights are planted at four opposite points to form a square in an eight-pointed star, which outlines the fortification. The fifth light is directly in front of the goddess's nose. The reflectors are tilted to throw the light upward at an angle of about forty-five degrees. The lighting was witnessed by enormous assemblages of people at the Battery, and along the wharves. The water was alive with craft of all kinds. When the signal for lighting was given fireworks in bewildering profusion blazed from the forts, islands, wharves, and vessels, followed almost immediately by a flashing white light from the torch, which sent dazzling rays over the waters of the harbour and far out to sea. The effect was marvellously beautiful. Tremendous roars of delight broke from thousands of throats, accompanied by the shrill whistles of every tug and steamer in the harbour. The lighting of the torch was pronounced successful, but that of the statue itself not. Held high above the statue's head, the light from the torch makes a brilliant beacon for the entire harbour, and is plainly visible for many miles at sea. The arm holding it is in shadow, and at a distance of a mile the statue itself is invisible. It is intended to remedy this by a different arrangement of the lower lights. Seen from Brooklyn Bridge the light of the torch is brilliant, but only the pedestal and uplifted arm are visible.

MILITARY TELEGRAPHS.—Colonel Macdonald, Commandant of the Queen's Edinburgh Rifle Brigade, has devised a very useful and compact equipment for the purpose of a regimental field telegraph, as distinguished from the divisional field telegraph. Colonel Macdonald expresses his views upon this point in the following words:—"It is highly desirable that every regiment should carry its own telegraph appliances, so that it may establish telegraphic communication with its own outposts when acting alone, and that when acting with others telegraphic communication may be more rapidly established by each regiment laying its own cable on reaching camping ground, instead of the whole telegraphic plant for a division being carried in separate waggons and worked by a separate department. This field telegraph is designed to enable the necessary plant for telegraphing to be carried regimentally. It consists of:—1. One mile of double conductor insulated cable. The main wire is in the centre, and covered with insulating material. The 'return' consists of five small wires wound round the covering of the inner wire, and this is again covered. The 'return' thus makes the obtaining of an 'earth' unnecessary, and also acts as a protection to the main wire. The cable is wound in two lengths on two bobbins. 2. Telephone transmitters and receivers for ordinary speech, or, where articulate sounds cannot be heard, a special arrangement by which the Morse alphabet can be read by telephone. (This latter instrument is designed by Samuel Vyle, Esq., late of the Telegraph Department, G.P.O.) 3. A special coupling for rapidity, and which avoids the use of all screws, which might get lost, or sockets, which might get clogged, in the rough usage of a field telegraph. 4. Poles to carry the cables across roads where traffic might injure it. The guying arrangements of these poles make them adaptable to any position, and enable the erecting, taking down, and re-packing to be effected with great speed. 5. Two bicycles to carry the plant. The poles are carried over the handles of the bicycles, and each bicycle has a half-mile bobbin supported on its backbone. The bicycles are trundled by the telegraph troop, the draught being extremely light. If surprised, the poles, which are of comparatively trifling value, can at once be thrown off and the bicycles mounted for escape." The apparatus is on view at the Edinburgh Exhibition, and has been awarded a silver medal.

THE RESISTANCE OF SOFT CARBON UNDER PRESSURE.—The true cause of the variation in the electrical resistance of soft carbon under varying pressure has long been and still remains a vexed question. The tendency has been to regard the result as being due merely to the variation in the extent of the surfaces in actual contact; but while no one has questioned that this is a *vera causa*, it remains doubtful whether the whole of the observed effect is due to this cause, or whether an actual variation in the specific resistance of the carbon does or does not account for some part of the phenomenon. Prof. Mendenhall has always upheld the latter theory, and writing to *Silliman's American Journal*, he now adduces the results of some experiments which offer in his opinion conclusive evidence of the existence of a variation due to this cause. For hard carbons a certain small variation of specific resistance with pressure was established by Mr. Tomlinson some five or six years ago, as the result of experiments which were at that time communicated to the Royal Society, and this fact alone must be allowed to afford *primâ facie* evidence on behalf of Prof. Mendenhall's theory. The professor conducted his experiments upon a thin diaphragm of soft carbon, which by ingenious manipulation was made to separate the horizontal limb of a U tube into two equal parts. Mercury was then poured into either side, and platinum electrodes dipping into the mercury enabled the circuit to be completed through the disc. It may then be fairly assumed that after the mercury has attained a certain height on either side the surface contact is fully established, and will be independent of any further addition to the statical pressure. If this assumption be challenged, it is still open to anyone to decline to admit the validity of the professor's conclusions. The additional pressure was obtained by means of compressed air, which was admitted upon either side of the mercury column. The electrical connections for measuring the resistance of the disc were of a very simple character, and do not require any detailed description. "Very many experiments were made, all without exception showing great diminutions in the resistance of the disc by increase of pressure." It was even found that the arrangement was sufficiently sensitive to show very slight changes in atmospheric pressure. The disc recovered its normal resistance with rapidity upon the removal of a small stress, but with heavier stresses the recovery was slow and sometimes imperfect. The results were independent of the current employed in the measurements so far as the observations extended. When a disc of hard carbon was employed the diminution of resistance under pressure was far less marked; and inasmuch as the "surface contact" under slight pressure is less perfect with hard than with soft carbon, Prof. Mendenhall considers this as an *experimentum crucis* on behalf of his theory.

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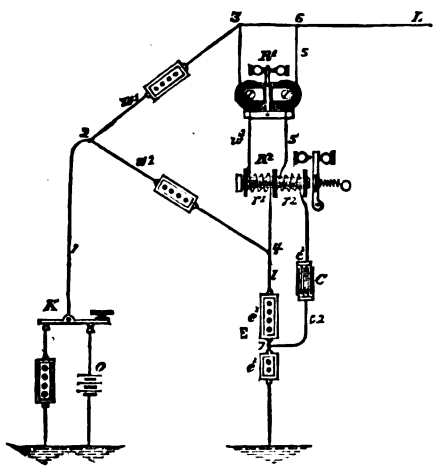
A NEW ARRANGEMENT OF THE QUADRUPLEX.

There has recently been introduced on the lines of the Baltimore and Ohio Telegraph Company a new arrangement of the quadruplex devised by Mr. Wm. Maver, jun., and designed to more perfectly overcome or counterbalance the effects produced by the static discharge of the main line.

The arrangement consists, in general terms, in applying to the coils of the receiving-instrument supplementary or additional coils included in a conductor extending from the main line to one plate of a condenser, the remaining plate of which is connected with the artificial line at a point between the earth and a portion of the artificial resistance.

The accompanying diagram explains clearly the connection of the circuits. Here L represents the main line and K a key system for transmitting from the battery O. A conductor, 1, leads from the key to a point, 2, where the two arms w^1 and w^2 of a Wheatstone bridge diverge. The arm w^1 is connected with the main line L at a point, 3. The arm w^2 is connected with an artificial line, l, at a point, 4. The points 3 and 4 are connected with each other by a bridge conductor, w^3, in which there are included one coil or set of coils of the two receiving instruments R^1 and R^2.

The instrument R^1 is represented as a polar relay, and is provided with a second set of coils included in a conductor, 5, leading from a point, 6, in the main line to a plate, c^1, of a condenser, C. The instrument R^2, which is represented as a neutral relay, is also constructed with two coils, r^1 and r^2, the former of which is included in the bridge conductor



New Arrangement of the Quadruplex.

w^3, as already stated, while the second coil r^2 is included in the conductor 5. The remaining plate c^2 of the condenser is connected with the artificial line l at a point, 7, intermediate between the two sections e^1 and e^2 of the artificial resistance E, employed for equalising the line resistance. The coils of the instruments R^1 and R^2 are so connected in the conductor 5 that the effects of the discharge of the condenser through them shall tend to neutralise the discharge of the main line. It will be readily understood that the charge taken by a condenser will depend upon the difference in potential of the points 6 and 7, with which the respective plates are connected. For this reason a portion, e^1, of the resistance E is located between the point 7 and the bridge, and the greater the amount of this resistance the greater will be the charge taken on by the condenser. It is desirable also that a portion of the artificial line resistance shall be between the point 7 and the earth.

It will be apparent that when a current is transmitted from the battery O to line, a charge will be received by the condenser C. The discharge of the line L will tend to produce a false signal by traversing the bridge conductor w^3. The current or impulse from the plate c^1 upon the discharge of the condenser C, however, will neutralise the effects of the line discharge in the receiving instruments It is also apparent that by a simple arrangement the resistance e^2 could be obtained from the coils of the rheostat used to form an artificial line in duplex or quadruplex telegraphy, thus dispensing with the expense of additional rheostats.—*Electrical World* (New York).

NEW EXPERIMENTS UPON THE ELECTRIC TRANSPORT OF FORCE.

M. Hippolyte Fontaine has recently been engaged in experimenting with some new Gramme machines specially designed for the transmission of force. We gather the following details from a note upon the subject presented to the Academie des Sciences by M. Mascart upon the 26th of October:—The experiments were carried out at the workshops of the newly-formed "Compagnie Electrique," whose existence we notified last week. The machines were constructed to the design of M. Gramme himself, and under his personal superintendence. The generators and motors were identical in type—a feature which is not in accordance with modern English practice in low tension transmission. Seven machines were employed, four of which were driven as dynamos, being connected in series to obtain high E.M.F., and the other three were employed as motors. The latter were also coupled electrically in series, and their armature shafts were connected mechanically by means of a pair of Raffard's flexible couplings.

The armatures of these machines were of the ordinary Gramme type, the ring having a diameter of 30 centimetres, and a breadth of 35 centimetres, and being wound with 200 coils. The resistance between the brushes measured 4·75 ohms.

The field-magnets are of the single horseshoe type, of cast iron, and are so arranged that the whole frame of the machine, including "the core which receives the wire, the pole pieces, and one of the plummer blocks," are cast in one piece. The resistance of the field-magnet coils is 6·65 ohms; the total internal resistance is therefore 11·4 ohms. From certain preliminary trials made with each machine separately it appeared that a current of 11 amperes could be passed through the machine for twenty-four hours without excessive heating, and that an E.M.F. of 1,600 volts was the maximum that could be obtained before the efficiency began to diminish. To obtain this E.M.F. it was necessary to drive the machine at 1,400 turns per minute, which gives the somewhat excessive circumferential speed of 4,080ft. per minute. "At speeds varying from 100 to 600 turns per minute an electrical efficiency of 79 per cent. was obtained, and between 600 and 1,400 revolutions the efficiency increased to 81 per cent.;" it may be added that the latter figure is equivalent to a commercial efficiency of rather less than 75 per cent. calculated on the cold resistance of the coil.

An artificial resistance of 100 ohms was placed between the two sets of machines; the experiments therefore apply to the case in which the line wire has a nearly perfect insulation. The horse-power expended was calculated by taking indicator diagrams from the cylinder of the engine when driving alternately (1) the dynamo, (2) a Prony brake. In the absence of a reliable transmission dynamometer, and provided that the load upon the brake did not differ much from that upon the machine, this method is no doubt capable of a very fair degree of accuracy.

The following table refers to some experiments which were made on the 19th ult:—

Revolutions of dynamos per minute	1,298
" motors " "	1,120
Difference of potential at the terminals of the four machines in series	5,996 volts.
Current	9·34 amperes.
Resistance of line	100 ohms.
Brake horse-power delivered on driving-shaft	95·88 h.-p.
" " received " "	49·98 "
Commercial efficiency.....	52 per cent.

The total weight of the seven machines was 8,400 kilogrammes, and the total cost 16,450fr. This represents 167 kilogrammes per horse-power transmitted, at a cost for the machines of 2fr. per kilogram.

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THE STOCKWELL ELECTRIC MOTOR.*

Among the electric motors which have come into extensive use in the United States is the Stockwell motor, which has for some time been employed in the running of light machinery, especially sewing machines, and it is said that not less than a thousand of these are in actual service to-day.

The motor, which we illustrate in the engraving, Fig. 1, is enclosed within a case, one end of which is removed so as to expose the interior. The magnets are of the converging, consequent pole type, and form an integral part with the top and bottom of the casing. The two sides are cast separate and held together by screws.

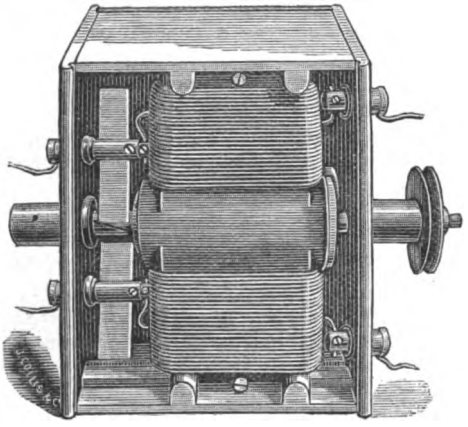

FIG. 1.

The armature, or more correctly the armatures, for there are two of them, are shown in Fig. 2. As will be seen they are of the Siemens shuttle-wound type, and are placed at right angles to each other. The commutator has four segments and the terminals of the wire on each armature are connected to opposite segments. The latter are not made parallel with the spindle, but are helical in shape, so that there is no break in the circuit at that point, since the brush passes the current to one armature before leaving the

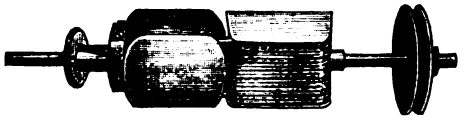

FIG. 2.

other. By this arrangement only one armature is in action at one time, the cut-out being effected just before the armature pole approaches that of the magnets, so that there is no dead point, and the motion is smooth and continuous.

Where the motors, as usual, are connected in series with each other, an adjustable resistance is provided which is contained within a box, such as that shown in perspective

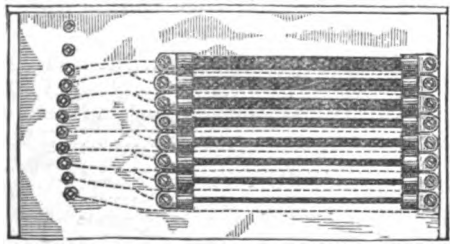

FIG. 3.—Diagram of Resistance Bars.

in Fig. 3. This adjustable resistance is placed in a shunt to the motor, and consists in a series of carbon bars of gradually decreasing conductivity. As the switch lever is passed over the successive contacts, increasing resistances are introduced in the shunt, which consequently allows more current to pass into the motor and increases its speed correspondingly. The spring attached to the switch lever keeps the latter in the position of "no current" in the motor, and by attaching a cord or other device connected to a treadle the operator on a machine has both hands free to work with.

The carbon resistance bars are copper-plated at their ends and firmly clamped, and by making them of gradually decreasing cross-section a relatively greater increased resistance is thrown into the circuit as the switch-lever passes from one contact to another. A wide range of control is therefore afforded with a comparatively limited movement of the lever.

The motor is provided with a clamp so that it can be readily attached to a table or work bench, and its simplicity of construction makes it little liable to get out of order.

* From the New York *Electrical World*.

THE ELECTRO-MAGNETIC ROTATION OF THE PLANE OF POLARISATION OF LIGHT IN IRON.

By A. KUNDT, in *Wied. Ann.*, Vol. XXVII., 1886.

In a former paper the author showed that iron, nickel, and cobalt rotate the plane of polarisation in the positive direction, and that the rotation is enormously greater in these bodies than in other magnetic and diamagnetic substances.

Dependence of the Amount of Rotation on the Intensity of the Magnetic Field.

In the case of all diamagnetic and feebly magnetic bodies, the amount of rotation for light of given wave-length, traversing a given thickness of the substance in a uniform magnetic field, may be assumed to be proportional to the magnetic force parallel to the beam of light. In fact, the amount of rotation per unit length of the substance in a field of unit strength, when the light rays are parallel to the lines of force, is what is known as Verdet's constant. Now, as the author has found so far, that in diamagnetic and feebly magnetic bodies the induced magnetism is also proportional to the magnetising force, it may be said, in the case of these substances, that the rotation for each element is proportional to the component in its direction of the magnetic moment at the position of the element. In the case of iron, cobalt, and nickel, however, the induced magnetism is not proportional to the magnetising force, but increases, at least in iron, at first more rapidly than the magnetising force, then more slowly, tending ultimately towards a maximum limit; and the experiments showed that in iron the rotation was not proportional to the magnetising force, but it also approached a maximum limit, so that in the case of iron Verdet's constant has no meaning, and one can therefore no longer speak of a specific rotatory power of iron, as was formerly done by the author.

It was found, however, that the maximum rotation was, within the limits of accuracy of the observations, proportional to the thickness traversed, which gave a new specific constant to be determined, viz., the maximum rotation per unit length.

Method of Observation.

The layers of iron were obtained, as in the author's former researches, by electrolytic deposition on platinised plates of thin glass of the kind used for covering microscopic slides. The glass alone only gave a rotation of 20′ or 30′ in the magnetic field used for the observations. The magnetic field was produced, as before, by means of a Rhumkorff electro-magnet of the ordinary construction, excited by means of a Gramme machine, the current from which could be varied by altering the resistance in the circuit. The small portion of the magnetic field included between the hollow portions of the conical pole pieces was sensibly uniform, and this was the only portion of the field that was employed; its strength was determined by measuring the rotation produced by a glass plate which had had its rotatory powers previously compared with

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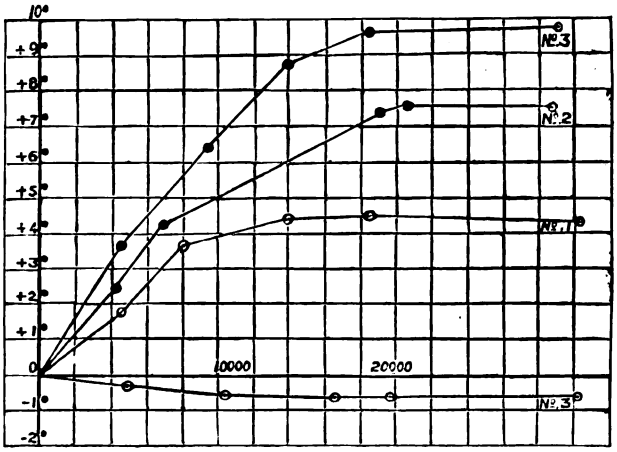
some substance for which Verdet's constant was known, such as water or bisulphide of carbon.

Sunlight having passed through a red glass of such a tinge that its mean ray approximately corresponded to the Frannhofer line C, was polarised by means of a Nicol prism, and allowed to traverse the metallic layer, passing through apertures left for that purpose in the pole pieces.

The accompanying diagram shows the nature of the relations



between the intensity of the magnetic field and the amount of rotation produced, observed with three films of different thicknesses, as shown by the three curves in the upper portion of the accompanying diagram, in which the ordinates represent the intensity of the field in C.-G.-S. units, and the abscissæ represent the corresponding rotations in degrees.

Maximum Rotation per Unit Length.

To determine the maximum rotation per unit length, six of the iron layers had their thicknesses determined by weighing. A very accurate determination could not be expected, as the method of weighing would merely give the average thickness.

The results are given in the accompanying table, in which

d = thickness in centimetres of layer of iron,

Ω = total observed maximum rotation in degrees,

ω = maximum rotation in degrees per centimetre length.

d.	Ω	ω
.0·00000419	1·66°	396000°
0·00000592	2·00	338000
0·00000759	3·20	422000
0·00001025	4·97	485000
0·00001148	5·38	467000
0·00002123	8·51	401000
	Mean	418000°

The numbers in the third column differ considerably, as was to be expected from the roughness of the method; but though the existence of any law connecting the amount of rotation with the thickness cannot be inferred from them, as a first approximation the rotation may be assumed to be proportional to the thickness, and on this assumption the observations give the result that the simple rotation per centimetre in iron magnetised to its maximum intensity is roughly equal to 200000°, or the rotation in a length of ·01mm. is rather greater than π. The strength of the magnetic field was about 20,000 C.-G.-S. units, and increasing the strength of the field beyond this value does not cause a sensible increase in the rotation, as is clear from the curves given in the diagram.

It would be of great importance to obtain a determination of the magnetic moment of the layers as a function of the intensity of the field in order to see whether the rotation is proportional to the magnetisation. The author has not succeeded in finding any simple method of determining the magnetic moment of a layer placed transversely in the field, but it was easily found that when placed longitudinally the magnetic moment reached its maximum value in a field of the strength of about 2,000 C.-G.-S. units.

Reflected Light.

In the case of rays normally incident on the magnetised iron layers it was also found that the rotation was not proportional to the magnetising force, but that it attained a maximum with a strength of field of about 20,000 C.-G.-S. units.

The results of these observations are shown graphically in the lowest curve of the diagram previously referred to. The amount of rotation was found to depend on the thickness of the layer, but more particularly on the nature of its surface. In the case of the layers of iron, nickel, and cobalt, the presence of a film of oxide, which produced little or no effect on light traversing it, produced a great disturbing effect in the case of reflected light, sometimes strongly rotating the plane of polarisation, sometimes producing an elliptic polarisation of the reflected light, so that very little difference in clearness was perceived on rotating the Nicol prism. On warming the iron layer, so as to cover it entirely with a film of oxide, hardly any rotation was observed.

It is easily seen that very little rotation would be caused by the film of oxide in the case of light traversing it, but in the other case a portion of the plane polarised light incident normal to the surface, would be reflected at the outer surface of the film of oxide, and a second portion would be reflected at the surface separating the oxide from the metal. Rotation of the plane of polarisation takes place only in the case of the latter portion, and the two portions of the reflected light interfere.

In all experiments on the rotation of the plane of polarisation by reflection the greatest care must therefore be taken to ensure the absence of any trace of oxide from the surface of the metal.

Remark on the Negative Rotation of Solutions of Magnetic Salts.

Verdet has shown that a concentrated solution of chloride of iron gives a negative rotation, viz., in an opposite direction to that produced by a diamagnetic body, and that many salts of magnetic metals are able, at any rate, to diminish the rotation which would be produced by the solvent alone. These phenomena, which seem to show an opposite behaviour on the part of magnetic and diamagnetic bodies respectively, with regard to electro-magnetic rotation, are of importance with respect to the true nature of magnetism and diamagnetism, and Maxwell says ("Electricity and Magnetism," Vol. II., p. 412, Second Edition):—"This shows that the difference between ferromagnetic and diamagnetic substances does not arise merely from the magnetic permeability being in the first case greater and in the second less than that of air, but that the properties of the two classes of bodies are really opposite."

He adds, it is true, that all magnetic substances do not show negative rotation, nor all diamagnetic substances positive rotation, as, for example, the neutral chlorate of potassium, which is diamagnetic, and gives a negative rotation.

This conclusion of Maxwell's and all attempts to explain the negative rotation produced by many salts of magnetic metals by means of the negative rotatory power of the magnetic atoms must be abandoned, since iron, nickel, and cobalt themselves produce a positive rotation.

The author points out that possibly some light may eventually be thrown on the reason of the different behaviour of iron itself and its salts, by the observation that all elementary substances hitherto examined, whether strongly magnetic or strongly diamagnetic, show a positive electro-magnetic rotation, a negative rotation being only shown in the case of chemical compounds.

The elements which have been shown to give positive rotation are Fe, Co, Ni, Br, Se, S, P, C (the diamond), O, N, H. Negative rotation is only shown by chemical compounds containing atoms which are strongly magnetic, such as salts of iron, &c.

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NEW METHOD FOR DETERMINING THE TIME OF OSCILLATION OF A MAGNET.

In a recent number of the *Annalen der Physik und Chemie* H. G. Hausemann describes a new arrangement for determining the periodic time of a suspended magnet. This method, which can be adopted for any similar purpose, consists of an ingenious application of photography for recording the differences of agreement in position between the magnet under observation, and a seconds-pendulum. The magnet is provided with a mirror in the ordinary way, by reflection from which the divisions of a scale mounted before it can be read off in a telescope. A small mirror fixed to the pendulum and parallel with its plane of oscillation, reflects when at rest the beam of an electric light on to a prism, provided with a broad slit crossed by a narrow vertical bar; from the prism the light is reflected on the mirror of the magnet, from which, when near its neutral position, the barred slit is focussed in a small photographic camera specially constructed for the purpose. The slide of the latter is furnished with a micrometer screw, so that the plate can be moved through a known distance between any two exposures. The elongations can be read on the telescope in the usual way, and by measurement of the distance between the images on the negative, the number of oscillations of the magnet corresponding to a given number of those of the pendulum can be accurately determined, if the times of exposure are chosen when the pendulum and magnet are both near their positions of rest. This method naturally admits of extreme accuracy in the determination of the quantities sought for, besides reducing the time required.

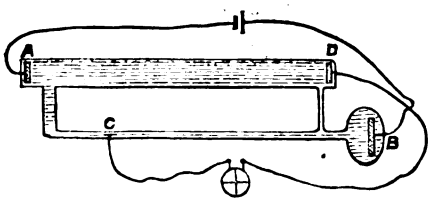
ON ELECTROLYSIS.

BY PROF. OLIVER J. LODGE, D.SC.

(Concluded from page 518.)

Surface Films.—Among bad conductors, the films on the surface of glass rods are to be remembered and studied. It would be interesting to know the absolute resistance of some such films, if it be possible to specify their conditions. Optical observations, combined with electrical conductivity determinations, like those of Reinold and Rücker with soap films, may be expected to lead to further knowledge of their thickness, nature, &c. A hygrometer founded on the resistance of such films would perhaps indicate not what is ordinarily called the "humidity" of the air, *i.e.*, its nearness to saturation, but its actual vapour pressure.

Possible methods of answering Question 1.—I find it difficult to make useful suggestions with regard to an experimental attack on the question of Ohm's law in electrolytes. It is to be remembered that experiment is useless except on a very good and well-considered plan. Something like 1 in 1,000 accuracy must be obtained, and higher may be aimed at. Although the best experiments hitherto are probably those of Kohlrausch and Nippoldt with alternating currents, it does not seem to me that such currents, employed with electrodes, are suitable for a really accurate determination. The capacity of polarisable electrodes is enormous, and apparently instantaneous, and the use of alternating currents by no means avoids effects due to this polarisation; although it is possible very nearly to eliminate these effects by calculation, as Kohlraush did. Methods of avoiding all polarisation, by working in closed circuits wholly electrolytic, are tempting. Such, for instance, as the damping effect, when a magnet swings over a liquid, or when a vessel of liquid is spun between the poles of a magnet (*e.g.*, Guthrie and Boys).* The electrolyte may be made to partake of the motion of the vessel by using a jelly. But the calculation of such experiments would (to me, at any rate) be difficult, and it is not likely that the experiments themselves are susceptible of minute accuracy. Probably the best plan of research would be some modification of the ingenious method planned by Maxwell for the British Association Committee on Ohm's law in metals. (See Brit. Assoc. Report, Glasgow.)



If perfectly similar tapping electrodes could be got, it would be sufficient to compare the E.M.F.s at the ends of two troughs or tubes, one wide, the other narrow, placed in series, so that the same current might flow through both. A null method of comparing E.M.F.s is simple enough. For instance, a liquid Wheatstone bridge might be made, one branch consisting of the very wide and very narrow tubes, the other of a uniform tube or trough of moderate width (see figure). A and B are battery electrodes, while C and D, which are carefully chosen, make connection with an electrometer, C being movable. A galvanometer seems dangerous, as allowing slight currents, which might disturb the equality of the tapping electrodes. The liquid employed might be chosen for convenience, and a natural liquid to use would be sulphate of zinc, with amalgamated zinc electrodes. It is not to be assumed that the polarisation of these is really nil, but it is certainly feeble, and will thus diminish the uncertainty and risk of error attending the experiment.

To avoid difficulties due to the inevitably unequal rise of temperature, an intermittently strong and weak current can be employed, as in the Maxwell-Crystal method* (cf. Schuster, Brit. Assoc. Report, Belfast). If any positive discrepancy were obtained, it would be necessary to consider to what it was due, and whether the effect of *surface* had anything to do with it. The fine tube might, for instance, be replaced by a tube packed full of thin glass rod, so as to have about the same capacity, but much more surface.

3.—*Are Electrolytic and Metallic Conduction thoroughly distinct, so that no substance has a trace of both conductivities at once?*—In other words, has any electrolyte a trace of metallic conductivity? or can any compound metal experience a trace of electrolysis? Is electricity able to slip through or among ions, instead of necessarily propelling them; and is it able to do both things at once? A positive answer to this question need not be given in the form of a disobedience to Ohm's law, for there is no reason for supposing that a metallic slip of electricity through the ions would be more prominent with small than with great current intensity. Insufficient polarisation E.M.F., and constant leakage of a current against it, are the facts which have caused many experimenters to suspect such metallic slip; but secondary actions would so easily account for the same thing, that it is necessary to be extremely cautious in interpreting such observations. Helmholtz's air-free cell proves that if any effect of the kind takes place it must be excessively small for ordinary acid (Faraday lecture). Clerk's experiments show that no such explanation of the behaviour of certain anomalous fused salts is *necessary*.† But it is impossible to give a certain negative answer to the question, on experimental grounds, until every substance has been tried with minute quantitative accuracy. A positive answer for any substance would of course be a denial of the applicability of Faraday's law to that particular electrolyte.

To the second half of the question,

Can any metallic alloy conduct electrolytically?—Seems easier of attack. Experiments have been made, on tin and lead, potassium and sodium, sodium and mercury, gold and mercury, cast-iron, with negative results so far.‡ But none of these alloys except sodium and mercury are well chosen. It would seem advisable to choose two metals far apart in the voltaic series, or in the thermo-electric series, so that one might cling more to positive electricity, and the other more to negative, if possible. Or they might be chosen with their so-called "specific heats of electricity" very different. Or, again, it may be well to choose two metals differing considerably in conducting power, so that one might be rubbed along with the current, so to speak, more than the other. I might suggest gold and lead, or copper and tin,§ or copper and zinc, or bismuth and antimony; beside, of course, mercury and zinc, or mercury and sodium, or, again, copper and zinc dissolved in mercury, &c. But it is to be remembered, from the experiments of Dr. Guthrie, Prof. Chandler Roberts, and others, that diffusion in all such cases is excessively rapid, and that precaution must be taken to diminish its effect in restoring uniformity of composition. A U tube with a constriction at its bend might be used, the whole filled with homogeneous alloy, and kept just above the fusing-point. Pass a very strong current through the U, and gradually cool down till the whole is solid, keeping the current on all the time. Then analyse the two legs, and see if they show any difference in composition.

4.—*Is there any relation between Optical Opacity and Electrolytic Conductivity?*—Metallic conductors are opaque, but electrolytic conductors are, ordinarily speaking, transparent. At the same time, ordinary water is by no means so transparent as bisulphide of carbon; it absorbs a great deal of some kinds of radiation. Does this opacity increase as conductivity increases, say by addition of acid, and diminish as the water becomes purer; or is there no relation between conductivity and opacity in liquids? Vision through long tubes is the simplest mode of attacking the question, but to get anything like a complete or satisfactory answer, the absorption spectrum of liquids in the less refrangible ultra-red region would have to be observed.

There are two obvious ways of explaining the transparency of a conducting liquid on the electro-magnetic theory. One is to assume that the minute and rapidly reversed electromotive forces which constitute light are incompetent to effect anything like alternate decomposition and recombination, so that the liquid to such forces behaves exactly like a dielectric; a supposition which would be equivalent to admitting a slight disobedience to Ohm's law, and which is a very reasonable one. The other is to assume that electrolytic conduction only occurs among *dissociated* atoms, and that these free atoms constitute so small a percentage of the total number as not appreciably to affect the transparency or dielectric character of the bulk of the liquid. On this second hypothesis, however, some slight absorption of radiation ought to be expected, and it might increase as the conductivity, *i.e.*, percentage of dissociated atoms, increased.

It may be difficult to maintain perfect homogeneity if change of tem-

* *Proc. Phys. Soc.* or *Phil. Mag.*, 1879 and 1880.

* *Brit. Assoc Report*, 1876, p. 36, Glasgow

† *Phil. Mag.*, June, 1885.

‡ In Mr. Shaw's very useful article "Electrolysis," in the *Ency. Brit.*, the slip is made of saying that these alloys have been electrolysed.

§ Prof. Roberts' curious alloy, $Sn\,Cu_4$, is well worth trying; see *Phil. Mag.*, Dec. 1879, p. 558.

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perature be attempted, else, of course, warming a liquid ought, on this second hypothesis, to make it less transparent.* On the first hypothesis it is possible that exceedingly intense radiation might develop an opacity in liquids quite transparent to ordinary light.

5.—*Under what circumstances is solid matter deposited in the path of a current.*—It is known, from the experiments of Davy and others, that if at the junction of two liquids the opposite ions can form an insoluble compound, then such insoluble compound is formed, those ions drop out of action, and others have to convey the current. For instance, if a current be sent from a vessel containing a barium salt to another containing a sulphate, through an intermediate vessel containing, say, dilute HCl, then $BaSO_4$ is precipitated in this vessel. I propose to make this intermediate vessel in the form of a tube, and examine whereabouts this formation of $BaSO_4$ first appears; varying intensity of current, density of solutions, &c.; and other similar experiments. (See Question 7).

Sir William Thomson, at the meeting, made some important observations about deposits of solids in general, and about the possibility of a long-established current producing solid concretions of a nature not naturally to be expected. As, for instance, nodules of copper in the sawdust of a Menotti cell, possible accretions in the joints of animals, &c. Some porous substance seems most likely, according to present observations, to have such crystals and nodules formed in it, and steady currents might be kept up through porous or cracked crockery, or sawdust, or sand, and secular observations made on the subject. It is not easy to see why deposits of this latter kind should appear, except by the reason of the surface action known as capillary E.M.F., and by some interference with Faraday's law; so that, for instance, the amount of copper going down current, and of SO_4 going up, should not be exactly equivalent, but a slight excess of copper be left, which has to drop out in mid-stream. If it is allowable thus to regard some deposits as isolated ions, their study becomes of considerable interest.

6.—*Is it possible for opposite corresponding Ions to travel at different rates?* The notion of different speed for different ions is founded upon the facts of "migration," but if it can be shown that migration phenomena can be accounted for in another and simple manner, all *necessity* for the hypothesis breaks down. There only remains the fact that some solutions conduct better than others; and this may be accounted for, either by greater speed of their ions, or by a greater number of dissociated atoms able to take part in the conveyance of electricity. It affords no answer to the question as to whether the opposite radicles travel at the same or at different rates.

In favour of Kohlrausch's and the customary migration theory, it may be truly urged that it is reasonable to suppose that each ion should have a rate of travel independent of any other from which it is completely detached; in fact, that it is difficult to see how the velocity of any given radicle can be controlled by the nature of the other radicle, which is travelling at its own pace in an opposite direction.

And *against* this independence of the corresponding ions I have only to urge that it would mean that an electric current could consist of *unequal* opposite currents of positive and negative electricity, and that in some cases at least this is certainly not true. Thus, in a simple fused or homogeneous electrolyte, it is quite certain that opposite ions are travelling at the same rate, and that therefore the current in them consists of *equal* opposite streams of positive and negative electricity. Now if such an electrolyte is put in series with salt solutions, and the same current sent through all, it is difficult to suppose that in one part of the circuit the current consists of equal opposite streams, and in another part of unequal; yet this is what Kohlrausch's theory necessitates.

Again, when a Holtz machine or other replenisher is used to produce a current, half the plate is carrying positive in one direction, and the other half is carrying negative in the other direction, so that in the visible convective part of the circuit it is easy to ensure the existence of equal opposite currents; and there is no evidence that the decomposition produced by such currents differs in any respect from that produced by equally strong voltaic currents. But whence the repugnance to admitting that a current may be at one place ½ positive and ½ negative, and at another place ¾ positive and ¼ negative? Only from the habit of picturing positive and negative electricity as both obeying the laws of an incompressible fluid, with identity or continuity of existence, and the consequent difficulty of supposing that ¼ stream of negative electricity and ¼ stream of positive can at one point rush towards each other, meet, and disappear, leaving no trace behind of either. For this is what must happen at the junction of a fused electrolyte, in which opposite ions are going at the same pace, with a dissolved electrolyte, in which the positive ion is travelling three times as fast as the negative ion. If there is no validity in the objection, then Kohlrausch's theory is probably true pretty much as it stands; but if any difficulty may be legitimately felt in the direction indicated, some modification must be made in Kohlrausch's theory.

7.—*On the apparent relative velocity of opposite Ions*—The facts of migration may, I believe, be accounted for by assuming that the solvent and the dissolved salt *both* conduct the current; but the result is to produce an apparently unequal velocity of ions, which has been mainly examined by subsequent analysis of the liquid near either electrode. I propose to examine it further by means of electrolytes in series:—*e.g.*, noting whereabouts in the path of a current a solid precipitate, caused by uniting ions, first forms. I am, indeed, now engaged in these observations (see Question 5).

A disobedience to Faraday's law of electro-chemical equivalence might in the same way be detected, either by an escape of an excess of one ion past another with which it should wholly combine and become insoluble, or by a deposit of the excess of one ion because it finds insufficient of the opposite ion with which to combine and remain soluble.

It may also be possible to examine the speed with which an ion, starting from a vessel at one end of a long tube, makes its appearance in another vessel at the other end of it, there being in this second vessel some sensitive chemical test for faint traces of it; such, for instance, as iron or sulpho or ferro-cyanide, silver in chloride, copper in ferro-cyanide. Or again, by putting a detecting substance in the tube, the journey of an ion may be continuously watched. Other things more or less vague might be tried; such as seeing whether there is any difference between applying a high E.M.F. to given electrodes in a long narrow vessel, and a small E.M.F. to similar electrodes in a short wide vessel, so that the same current goes through both. One must not expect any variation in the *primary* products of electrolysis probably, but there may be some difference in the secondary effects.

8.—*How much of the Current is conveyed by the water and how much by the dissolved salt in any given case?*—To answer this question it seems to me sufficient to determine the amount of free acid generated at either pole, and to compare it with the amount of metal deposited in the same time by the same current. For instance, with copper sulphate solution and platinum electrodes. If the salt conducted the whole current, one equivalent of free acid would be produced at the anode; if water conducted the whole, one equivalent of free acid would appear at the cathode. It is easy to see this by drawing the section of a cell and considering its action; and so, by determining the proportion of free acid which actually *does* appear at either pole for given strength of solution and intensity of current, it is easy to reckon how much of the current is by each substance conducted. It is obviously necessary to diminish diffusion between the cathode and anode vessels, and to avoid electric endosmose and the use of porous diaphragms. It is also probably advisable to stir or scrub the surface of both electrodes, so as to avoid a layer of some other liquid forming there, and so confusing the whole reaction.

Migration data, if explained in the way I suggest, will also give a determination of the proportion of current conveyed by salt and by solvent; and it will be interesting to compare the two methods of determination, and see if they give the same result. If there is a discrepancy, as is very probable, it will be necessary to examine its cause, and to see whether it wholly upsets the suggested migration hypothesis, or only entails some slight modification.

9.—*Is any quasi-electrolysis possible across an air-space?*—If there are in acid-water any free dissociated atoms electrically charged, it is just possible, though very unlikely, that they might be pulled out of the liquid by electrostatic attraction. Thus, if hot acid liquid be one plate of a condenser, the other plate being a hot metal slab half a millimetre above it, and kept at a very different potential, it is just conceivable that the evaporating steam might contain a trace of free hydrogen or free oxygen, according to the sign of the potential of the plate.

10.—*Does the energy of Secondary Action contribute to E.M.F. in a cell just as much as the energy of Primary Action, or do secondary actions directly generate heat?*—Dr. Wright distinguishes between what he calls "adjuvant" and "non-adjuvant" chemical actions in a cell—those which help the current on, and those which do not.

Lord Rayleigh raised the same question at the meeting, in considering a Clark cell; for the sulphate of mercury, being nearly insoluble, must certainly be mainly reduced by secondary action if anything like a current is kept going; and yet it seems to contribute to the E.M.F. of the cell. But one may ask whether the polarisation produced by a moderate current in such a cell is not evidence of the speedy exhaustion of the *dissolved* $HgSO_4$, and of the time taken to replenish the solution from the nearly insoluble paste, thus showing that it is, after all, the dissolved salt which is really efficient. Moreover, it seems to me that all reversible effects must contribute to the E.M.F. Helmholtz certainly considers the minor attraction of solvents to be as proportionally effective as the main affinities of ions. The behaviour of cells which are able to heat or cool themselves, and the variation of their E.M.F. with temperature, are of great interest in the light of the recent theory of Helmholtz. A result deduced from the second law of thermodynamics is pretty surely founded; but experimental verification is always satisfactory, and one can seldom have too much of it. The laws that want examining are these: Measure the total heat, H, developed per second in cells of various kinds (internal resistance R) by a known current, C; measure also their change of E.M.F. per degree of temperature, dE/dt; then see whether.

$$\frac{RC^2 - JH}{C} = (274 + t)\frac{dE}{dt}.$$

Further examine whether each of these quantities is also equal to the difference between the observed E.M.F. of the cell and that calculated from purely chemical data, viz., to $E - \Sigma (J\epsilon\theta)$.

11.—*Is specific inductivity a constant, or does it tend towards zero for very high strains in the same sort of way that magnetic permeability does?*—I am not aware that the capacity of a highly-charged condenser has ever been seriously measured. It seems a desirable but difficult thing to do.

12.—*How does dielectric strength depend upon density?*—Considerable work has been done in measuring the dielectric strength of different gases at various pressures, but we cannot be said to know the law even for air; nor is the truth about the great strength of approximate vacua on the one hand, and very high-pressure gas an the other, at all certain. The dielectric strength of insulating liquids ought also to be measured; and it might be tried how far pressure affects them. The effect of pressure upon electrolysis has been worked at, and may be said to be fairly understood. The effect of pressure on disruptive discharge, and the internal pseudo-conductivity of gases after elimination of discontinuities, such as cathode-resistance, is more obscure.

* It is here assumed that better conduction means more dissociation; this is not at all certain, it may mean less viscosity; and it apparently does mean this, for the case of rising temperature, though not for the case of increased complexity of constitution.

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CABLES TO NEW ZEALAND.

A writer in the current number of the *Fortnightly* says that this "is an age of loose thinking, and of looser writing; of idle words, servants to shallow fools." "Never, perhaps," he continues, "was there an age in which the trade of the sophist, whose business it is 'to make the worse reason appear the better,' was carried on so successfully. Never was there an age in which a writer who feels that he is 'a teacher or nothing' had greater need of well considered and accurate language." These words apply with peculiar force and directness to many purely commercial questions, and we think are applicable to the case submitted by the chairman of the Eastern Extension Company to the ordinary meeting of that company, held last week. We never remember a more direct appeal to the Press to take cognisance of a subject than was discussed at this meeting. The question is one of more than local interest, it demands attention outside a circle of shareholders or the governing body of a small colony. It appeals directly to the commercial, manufacturing, and working classes of the Empire. Putting aside for the moment the position of New Zealand in the cable system, we will start with the fact that the cable system of the world is an outcome of civilisation, that it is essential to the well-being of nations to the development of trade, and the progress of commerce. It is none the less a fact that this all-important link in the chain of civilisation is the result of private enterprise. No doubt the rapid development of submarine telegraphy has taken place with the assistance of subsidies from various Governments. The question originally for the consideration of New Zealand, or any other individual colony, was "telegraphic communication or no telegraphic communication." Private enterprise could hardly be expected to take all the risks, to expend hundreds of thousands of pounds in laying and maintaining cables, unless there was a good prospect of receiving interest upon the capital expended. Experience has shown that during a ten years' trial the return from the New Zealand cable did not give more without the subsidy than two per cent. on the capital invested after calculating amortisation. In other words, New Zealand has had the immense advantages of cable communication years before private enterprise could, under ordinary circumstances, have taken a cable there, solely through the subsidy granted by the colony, added to the receipts obtained from the undertaking, giving the investors a fair interest upon the capital expended. To put the matter in another way. The cable business obtained from New Zealand as a strictly commercial enterprise only pays two per cent. upon the capital—a return out of all proportion to the risk.

The present position is as follows:—The original agreement between the Cable Companies and the New Zealand Government came to an end by lapse of time eight months ago. Negotiations were opened with the Government to continue the subsidy for another ten years. From the first difficulties arose, but the Government at one time inclined to renew for five years. Naturally the company asked for the longer period, in order to pursue some settled policy, and to make the large reductions proposed in the tariffs relating to Intercolonial messages passing over the New Zealand cables. Constant changes are far from beneficial to any business concern, and especially is this the case in cable work, where tariffs, code books, and administrations are affected by every change. Ultimately the New Zealand Government declined to renew, even for five years, and refused arbitration on the question. So far as we know, not one single word has been said against the management of the Cable Company. Its work has been performed satisfactorily. The cable opened in 1876 has never been interrupted—a good proof of the care in its manufacture and in placing it in its position. Of course from time to time the question of tariffs being too high has arisen, but this is a purely financial question, and we think all adverse criticism falls to the ground when the interest paid to the shareholders is considered. That, surely, has not been excessive, nor has too large a sum been placed to reserve.

The result of the policy adopted by the New Zealand Government may not inaptly be termed the one man policy, as emanating solely from Sir Julius Vogel. This policy has led, on November 1st, to the raising of the tariff—a necessity, so far as the Company was concerned, in order to make up for the loss of the subsidy. The worst part of the business is that the New Zealand Administration have increased the terminal charges from 6d. to 4s. 6d. per ten words—an additional tax upon Australian telegrams paid solely by Australians, and intended to be used as a set-off against the Telegraph Company for its increased tariff. New Zealand, in fact, says: We intend to pay what we please for telegrams, whether it suits your shareholders or not, and if you increase your tariff we shall increase our terminal charges proportionally, so that we lose nothing. Commercial circles in Australia and New Zealand are not likely to remain quiet under these cir-

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cumstances, and already there are signs of rebellion against the action of New Zealand. No reason has been advanced for the policy, except that the renewal of the subsidy "would interfere with the laying of an opposition cable between Australia and Europe, *vid* the Pacific." This opposition cable seems to be favoured by Sir JULIUS VOGEL. Its promoters ask New Zealand for a subsidy of £20,955, as against £9,599, the guarantee for existing companies. The tariff of the proposed Pacific cable is to be 4s. per word, while the existing companies offer to give a 2s. 6d. tariff if they receive a subsidy equal to that asked for by the promoters of the Pacific cable. There is no doubt but that the Eastern Extension Company could arrange with the companies in connection with it to enable the proposal of a 2s. 6d. tariff to be carried out, or Mr. PENDER would have been less emphatic on this point. The above figures apply solely to the New Zealand contribution to the subsidy; the figures relating to the whole subsidy to be paid for both schemes will be found in our report of the meeting previously referred to. We have endeavoured to show that from a purely business point of view the action of New Zealand is surprising. Why should a subsidy larger in amount be paid when the lesser amount answers just as well. Or, if the larger amount is paid, why are the less facilities to be taken? We do not intend to re-discuss the Pacific scheme, having long ago pointed out the unbusiness-like character of the whole proposal. One phase, however, should not be overlooked—it is that should the scheme ever be carried out, the benefit will be almost entirely on the side of America, while England will proportionally suffer.

TELEGRAPHIC FRAUDS.

Under this heading a paragraph was published in our issue of the 1st October reflecting on certain of the "local officials of the Western Union Cable Lines," and in our next issue of the 8th October we published what we hoped would have satisfied anyone, that no accusation or imputation whatever was intended by us against any person connected with the receipt or forwarding in this country of any cable messages, and in what we thought, and still think, fitting terms expressed our regret for any pain or annoyance that the appearance of the paragraph might have caused. It has been represented to us, however, that from the terms in which our withdrawal was expressed there might possibly exist some misapprehension as to our meaning, and in order to obviate this we now unreservedly acknowledge that the statements contained in the paragraph of the 1st of October were entirely erroneous, and repeat our regret that it should have ever appeared, or have caused annoyance to any one connected with the Western Union Company. We think it only due to ourselves to state that the original paragraph was written and published during the unavoidable temporary absence of the responsible editor, and without his knowledge, an explanation that has already been furnished to the parties who have complained of the statements contained in it.

CORRESPONDENCE.

CABLE RATES TO NEW ZEALAND.

TO THE EDITOR OF THE ELECTRICIAN.

"SIR: As the dispute between the New Zealand Government and the Eastern Extension Company, to which reference was made by the chairman at the company's general meeting last week, is engaging considerable attention in the Australasian colonies and elsewhere, and as telegraphic communication is now so universally used, it may interest many of your readers to know the facts of the case. I am therefore directed by the chairman to send you the following outline:—

"In consequence of the serious inconvenience felt by the Government and public of New Zealand from the want of telegraphic communication with Australia and the rest of the world, an arrangement was made with my company in 1875 for the laying of a submarine cable from Sydney to Nelson, in consideration of the payment to the company of an annual subsidy for ten years of £5,000 from New Zealand and £2,500 from New South Wales.

"The cable was laid and opened for public use in February, 1876, and from that day to this has never been interrupted.

"In November, 1884, the company, finding that the earnings of the cable without the subsidy after nine years' working were insufficient, when working expenses and amortisation for renewing the line were deducted, to give more than a return of 2 per cent. upon the capital invested, opened negotiations with the Governments with a view to the renewal of the subsidy on its expiration in February, 1886.

"The New Zealand Government at first replied that the subsidy was no longer necessary, but the New South Wales Government expressed their willingness to renew their share of the subsidy for a further term of ten years upon the company undertaking to reduce the tariff for intercolonial telegrams over the New Zealand cable from 6s. per ten words to 5s. for ordinary messages, and 3d. per word for Press messages. The proposal was accepted by the company, and submitted by the New Zealand Government to their Parliament, but the latter negatived it, and would only agree to five years' renewal.

"Thereupon the company intimated that they would accept the shorter period, but as they considered the bargain under the circumstances a hard one, they could only give the reductions of tariff proposed by the New South Wales Government, provided the subsidy was renewed for the whole ten years.

"Subsequently the company submitted to the New Zealand and other Australasian Governments proposals based on the principle of guaranteeing the average earnings of the company for the past three years, for giving the colonies full control over the tariffs between Australia and Europe by making the rates any figure they pleased, and offered to accept the terms sanctioned by the New Zealand Parliament if the guarantee principle was applied to the New Zealand cable.

"This and all other proposals made by the company for bringing about an amicable arrangement having been refused, and an offer to refer the question to arbitration having also been rejected, the company have been reluctantly compelled to increase the tariff for intercolonial telegrams between Sydney and Nelson to 10s. per ten words from the 1st inst., in order to recoup the loss of the subsidy.

"The company have delayed taking this step for over eight months in the hope that the necessity for it might be averted, but having exhausted all conciliatory means of bringing about a satisfactory solution, the responsibility for the inconvenience caused to the public must rest with the New Zealand Government and not with the company.

"At one time the New Zealand Government threatened, if the tariff was raised, to withdraw the office accommodation which they are bound to give to the company for ten years after the expiration of the subsidy, but the company intimated that such action might compel them to close the cable and hold the Government responsible for damages, and the Government have not so far carried out their threats.

"The New Zealand Government now notify that their terminal rate of 6d. per ten words has been raised to 4s. 6d., and this amount the company are obliged to collect from the telegraphing public of Australia and add to their cable tariff, making the total rate for messages from the coast of Australia to New Zealand 14s. 6d. per ten words, against 10s. 6d. on telegrams from New Zealand to Australia.

"The New Zealand Government also intimate that they will not collect more than 6s. for the cable charge on telegrams emanating from New Zealand, but will apply their increased terminal rate on telegrams to New Zealand in payment of the increased cable charge, and thus relieve the New Zealand

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public at the expense of the telegraphing public of the other colonies.

"The company cannot, however, believe that the public will, for any length of time, allow this regretable state of things to continue, and as some of the leading Australian Governments and Chambers of Commerce in Australia and New Zealand are supporting the company's action, we are hopeful that before long an arrangement satisfactory to all parties will be arrived at.

"I enclose a copy of the whole correspondence on the subject, and would invite your special attention to the last telegram, giving a summary of an article in the *Melbourne Argus* on the subject, which shows how the question is viewed in Australia.—I am, Sir, your obedient servant,

"F. E. HESSE, Secretary.

"The Eastern Extension, Australasia and China Telegraph Company (Limited), Winchester House, 50, Old Broad-street, E.C., Nov. 2."

ELECTRIC TRAMCARS, &c.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your last issue, on page 507, you make a remark which has a peculiar interest to me, viz.: "Whenever a fresh start is made the coils of the motor are necessarily subject for a short time to a current far greater than they can safely bear for any length of time, and this certainly tends to render the question of heating of even greater importance than ordinarily in the case of motors employed for this special purpose." This point I saw during practical experiments with the first electric street car operated in this country, at a comparatively remote period. The result was that I patented a method of working which entirely obviates the rush of current through the motor, and the car can be started with no heavier current through the coils of the motor than is used when running easily on a level track. The whole progress of electric traction depends on its economy, and points of this kind are of great practical importance.—Yours, &c.,

RADCLIFFE WARD.

10A, Great Queen-street, Westminster, S.W.,
3rd November, 1886.

ERRATA.—Prof. Forbes writes to us pointing out that the following corrections must be made in the report of his paper "On Hysteresis," read at the late meeting of the British Association at Birmingham, which appeared in our issue of October 29. In reference to these corrections we may say that our report was obtained from the original MSS. handed to the reporter, and it will easily be seen how the errors referred to arose. An indistinct T was copied as 1, π as 11, H as 11, a for α.—ED. *E.*

page 513 line 64 *for* $\frac{1}{4}$ *read* $\frac{T}{4}$
" " 70 *omit* "due to the maximum force"
" 514 line 2 *for* Q Q *read* $Q Q_1$
" " 2 *for* P^1 *read* P_1
" " 3 *for* Q^1 *read* Q_1
" " 4 *for* $Q Q^1$ *read* $O Q^1$
" " 10 *for* $\frac{1}{4}$ *read* $\frac{T}{4}$
" " 10 *for* $\frac{1}{8}$ *read* $\frac{T}{8}$
" " 21 *for* $\frac{1}{4}$ *read* $\frac{T}{4}$
" " 24 *for* $\frac{1}{4}$ *read* $\frac{T}{4}$
" " 27 *for* abscissæ, O, A, *read* abscissa O A
" " 68 *for* Maxwell *read* Wherwell.
" " 68 *for* striction *read* stiction.
" " 90 *for* $\frac{11}{2}$ *read* $\frac{\pi}{2}$
page 514 line 90 *for* $\frac{K}{11}$ *read* $\frac{K}{H}$
" " 90 *for* $a\beta$ *read* $d\theta$.

I may mention that the letter A refers to the point where Ewing's (? Warbourg's) curve cuts the axis of abscissae.

REPORT OF AN AMERICAN TRAMWAY COMPANY.

In the report of the Baltimore Tramway Company for the year ending September 25th, Mr. Robbins, the general manager, bears the following valuable testimony to the thorough practicability and unqualified success of electric traction. He says:—

"Our success by the change from horse and mule power to electric power has exceeded my highest expectations. It has largely increased travel on the route, and at a less operating expense than horse-power. The road has been running more than a year by electricity with as much regularity as any road in the country. I find less difficulty in getting men to run the motors properly than I do to get men to run the ordinary horse car properly. The road is now being run by persons who, before their employment here, were unfamiliar with electrical affairs. The overhead conductors that have been lately put up to carry the current overhead at the road crossings are working very successfully. We are now extending the overhead conductor over another branch of the road, which we expect will be completed before many weeks." He then gives the subjoined figures:—

For the year ending Sept. 1, 1886, the road carried, with two cars propelled by Daft electric motors, 311,141 passengers at 5 cents each	$15,557.05
For the corresponding year ending Sept. 1, 1885, the road carned, with three cars propelled by horses, 227,155 passengers at 5 cents each	11,357.75
Showing an increased gross earning by two electric cars of over the gross earnings of three horse cars for corresponding time the previous year.	$4,199.30
The average number of passengers carried per car per annum by electric power was	155,570
The average number of passengers carried per car per annum by horse-power was	75,718
Showing an excess of passengers carried per car per annum by electric power of over horse power per car per annum.	79,852
The average gross earnings per car per annum propelled by electric power was	$7,778.52
Average gross earnings per car per annum by horse-power was	2,785.91
Showing an excess of gross earnings per car per annum of in favour of electric power per car per annum over horse-power per car per annum.	$3,992.61

The average cost of horse-power per car per day is $6.50 The cost of the electric power per day on this road is:

1½ tons of coal, at $3.50 per ton	$5.25
An engineer at	2.00
A fireman at	1.50
Oil and waste	0.50
Interest and depreciation of plant	2.75
Making	$12.00

the cost of ample electric power to run three cars and three motors, which is an average cost per car per day for electrical power of $4.00.

He adds: "When I take into consideration the largely increased earnings per car propelled by electric power over the earnings per car propelled by horse-power, I am very favourably impressed with the large percentage shown in favour of electric-power over horse-power for propelling street cars. There are not two miles of street railroad in the country more difficult to operate, owing to the unprecedented grades and curves to overcome than the two miles that are being successfully operated here now by electricity. There are not 300ft. of level track at any one point on the road. The grades vary from nothing to 350ft. to the mile, with curves from 40 to 70ft. radius on heavy grades. With more favourable conditions—such as cheaper fuel, easier grades and curves—a much more favourable result could be obtained than on this road."

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LEGAL INTELLIGENCE.

Bannatyne v. The Direct Spanish Telegraph Company (Limited).

This was a case heard by Vice-Chancellor Bacon, which came on upon a motion by Mr. Neil Bannatyne, at one time Chairman of the Direct Spanish Telegraph Company (Limited), and now a preference shareholder in the Company, on behalf of himself and the other holders of preference shares, against the Company, Sir James Anderson (its present Chairman), and the other Directors of the Company, for an interim injunction to restrain the defendants from acting on certain special resolutions passed by the Company for the reduction of their capital, and from presenting a petition to confirm the reduction.

Mr. Marten, Q.C., and Mr. H. B Howard (instructed by Messrs. Murray, Hutchins, and Stirling) conducted the case for the plaintiff; Mr. Rigby, Q.C., and Mr. W. P. Beale (instructed by Messrs. Blunt and Lawford) represented the Company; Mr. Burton Buckley appearing for the defendants, Sir James Anderson, and the other Directors.

Mr. MARTEN, Q.C., in opening the case for the plaintiff, said that the Direct Spanish Telegraph Company was registered on the 8th November, 1872, with an original capital of £130,000, in 13,000 shares of £10 each. By special resolutions of the Company passed in 1874 there was an increase made to the capital by the issue of 6,000 new shares at £10 each, making £60,000, all of which were paid up, being issued on the terms that they should have a preferential dividend of 10 per cent. per annum, and also, if there were insufficient money to pay such dividend, that it was to be made up out of the profits of any succeeding year. The dividends were paid on the ordinary shares of the Company up to the 30th of June, 1882, whilst the dividends on the preference shares were paid up to the 30th of June, 1884, since which time the money which was available for that purpose had been retained by the Company, with the result that they had now a reserve fund amounting to £14,300. The Company retained that money with the idea that in consequence of their loss of capital—or what was the same thing, the loss of one of their cables—they were bound to make good that loss. He ought to state that the 10 per cent. per annum on the £60,000 preference capital would amount to £6,000 a year, and what the Company purported to do by the special resolutions, which he would call his lordship's attention to, was this. They proposed to reduce the share capital by striking £5 per share not only from the ordinary capital but also the same amount per share from the preferential capital. By an arbitrary reduction of capital they reduced the amount of the preferential capital from £60,000 to £30,000. The result would be, according to their contention, that they would have to pay only £3,000 a year to the preference shareholders instead of £6,000, for which they originally bargained. In other words, they proposed to break the bargain upon the faith of which the preference shareholders entered into the Company and took their shares. On the other side it was suggested that if the Company were to be wound up the right of the preference shareholders to 10 per cent. per annum would avail them little, inasmuch as they could only share in such assets as there might be with the ordinary shareholders. That might or might not be the case, but it was sufficient for him to say that there was no idea of winding up the Company, which was now a going concern. The Company was reserving what should go in dividends for the purpose of making good what had been lost. That would end at a limited period of time, when the preference shareholders would enter upon their rights and would be entitled to be recouped for all the dividends temporarily withheld. With that statement of the case he would now ask his lordship's attention to the Memorandum and Articles of Association and to the terms upon which the preference capital was issued. Article 7 of the Articles of Association authorised the Directors, "with the previous sanction of a special resolution of the Company, to increase its capital by the issue of new shares to such an aggregate amount, with such preferential right to dividend, and such priority in the distribution of assets, or subject to such postponement of dividends, or in the distribution of assets, as should in such special resolution be provided." He did not think he would trouble his lordship with Article 8, but Article 9 provided that "all capital raised by the creation of new shares shall be considered as part of the original capital, and shall be subject to the same provisions in all respects as if it had been part of the original capital, except so far as these Articles, or the resolution authorising the raising thereof, may otherwise direct;" and Article 10 also authorised the Company by special resolution from time to time to reduce its capital, and to alter the amount and denomination of its shares. He did not think he would trouble his lordship by reading any other of the Articles of Association. He would now refer to the fact that there were passed on the 3rd of July, 1874, and confirmed on the 17th of the same month, special resolutions, by which the Directors were authorised to increase the capital by the issue of 6,000 new shares of £10 each, such new shares to be entitled to "a fixed preferential dividend of 10 per cent. per annum," and the deficiency in payment of such dividend in any year to be made up out of the profits of any succeeding year, as he had already told his lordship. As a matter of fact these shares were issued and paid up, and the plaintiff was the holder of some of them. On the 30th September of the present year, special resolutions were passed for the reduction of the capital, and were confirmed on the 19th of October. They were as follows:—"That in consequence of the abandonment of the Company's original cable, the capital of the Company be reduced from £190,000 (at present represented by 6,000 preference shares of £10 each, all issued and fully paid up, and 13,000 ordinary shares of £10 each, whereof 12,931 are issued and have £9 per share paid up, and 69 are unissued) to £95,000, and that such reduction be effected by writing off £5 per share from the amount credited as paid up on each issued share, and £5 per share from the nominal amount of each unissued share, the amount so written off the issued shares being capital not represented by available assets," and "That the Directors may make such regulations as they think fit for exchanging the certificates of shares for certificates in conformity with the foregoing resolution." He thought he had now stated the facts necessary to be brought before his lordship. He then proceeded to read from the affidavit of Mr. Neil Bannatyne, the plaintiff in the action, to show that that gentleman had attended both meetings, protested against the passing of those resolutions, and recorded his vote accordingly, on the ground that the effect of the resolution would be to deprive the preference shareholders of £3,000 per annum, or half the dividend they would be entitled to receive under the conditions upon which the preference shares were issued, and to put it into the pockets of the ordinary shareholders. He also quoted from the report and statement of accounts of Directors, presented to the meeting of the shareholders on the 30th September, as follows:—"The examination of the original Bilbao cable having resulted in showing that it could not be advantageously restored, the Company has now to adopt one of the alternatives pointed out in the opinion of Sir Horace Davey (to which reference has been made at previous meetings), and either discontinue the payment of dividend on all the shares (including the preference shares) until sufficient money is accumulated to lay a new cable, or else take steps to write off a proper amount of the existing capital as unrepresented by assets. The Board have considered the position carefully, and find that the former alternative would, with the present revenue, involve the suspension of all dividends for ten years. But, on the other hand, to place the Company in a sound and dividend-paying position by writing off the lost capital, the following step may be taken, viz., reduce the nominal capital by writing off £5 per share on all the shares. If this were done, the arrears of dividend on the preference shares (£2. 10s. per share to the 31st December, 1886), could be at once paid. [The report then gives the figures on which this calculation is based.] In the calculation the reduced ordinary shares are treated as £5 shares with £4 paid on each, thus leaving the £1 liability on the ordinary shares as at present, and the Directors consider that this liability should remain, as the debenture holders might object to the scheme if it were proposed to extinguish it. There is no occasion for calling up the amount at present. The accounts for the half year show, after providing for debenture interest, a balance to the credit of profit and loss of £4,573. 12s. 2d. The traffic receipts show an increase of £1,022 2s., as compared with the corresponding half year of 1885, and a decrease of £89. 10s. as compared with the last half year. The new Bilbao and the Marseilles-Barcelona cable continue in good working order. The Directors have already, by their circular of 16th July last, advised the shareholders of the result of the examination of the original Bilbao cable, and of the opinion of the firm of engineers, Messrs. Clark, Forde, and Taylor, who superintended the operations, to the effect that this line could not be advantageously restored, and the Board have accordingly abandoned it." He then read from the affidavits of Sir James Anderson and Mr. Henry Charles Forde, generally affirming what was contained in the foregoing statements, and proceeded to argue that the special resolutions passed at the meeting on the 30th September, and subsequently confirmed, were *ultra vires*. It was quite true that the Company were authorised to reduce their capital, but not so as to upset the conditions upon which a particular portion of that capital was issued. It was plain, however the matter might be obscured, that the fund which was now being accumulated, and would accumulate for a considerable number of years, would be distributed among the ordinary shareholders instead of being reserved to make good the capital of the Company. As matters stood upon the evidence of Sir James Anderson he agreed that a certain period must elapse before the profits could accumulate to such an extent as would enable the Company to pay dividends without having restored their capital. But there was no difficulty or obstacle in it. They were all familiar with cases of companies, such as water or gas undertakings, who were limited to 10 per cent. dividends, and who perhaps for a series of years never earned anything like that dividend, and who afterwards began to earn enough to pay their current 10 per cent, and make good out of the subsequent profits the sum that was necessary to recoup the shareholders who were entitled to it the full 10 per cent. In the same way, at the expiration of the 10 years the preference shareholders would have the capital restored to its original amount. That capital would be applied either to the reduction of debentures, whereby the position of the preference shareholders would be greatly improved, or put into investments, which would produce an income which would benefit the preference shareholders by increasing their security. When that period had elapsed the preference shareholders would, according to their bargain, enter into the receipt of their 10 per cent. per annum, and then they would be entitled to take the surplus until all their arrears were paid up. That was in accordance with the Articles of Association, and the special resolution of 1874. That was the bargain. Everybody knew perfectly well when that bargain was made that the Company was a Submarine Telegraph Company. Everybody knew the many contingencies to which such a Company was subject, as, for example, the liability to have its cables destroyed or rendered worthless by the action of the water or the scour upon them. These risks were contemplated, and the existing ordinary shareholders at that time thought it so expedient for the purpose of raising the necessary capital which was requisite for their then necessities that they entered into that bargain. He submitted, therefore, that it was plainly *ultra vires* for a body of shareholders to attempt thus to deprive the preference shareholders of that which was secured to them by their bargain. As he had said, the only argument suggested on the other side was that if the Company were wound up the preference shareholders would not have a preferential right in the distribution of the assets. That was unnecessary for him to argue. As he had pointed out, the Company was a going concern, and was not to be wound up. It was a prosperous Company, and

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although it had had one of those misfortunes incidental to all telegraph companies, that would be repaired in a short time, and eventually everybody would get fairly well paid, and therefore he submitted that there was no ground or justification whatever for the aforesaid special resolution. In support of his contention the learned gentleman quoted the case of Blisset *v.* Daniel, page 493, Vol. X. of "Hare's Reports," and also the decision of Vice-Chancellor Bacon in the case of Alhusen *v.* Borris, reported in Vol. XV. of the *Weekly Reporter*, page 739. He submitted, in conclusion, that in the present case the ordinary shareholders, who were in the majority, had no right to help themselves to a portion of that which ought to be appropriated by the preference shareholders. It would be contrary to the truth and justice of the case, and contrary to the express terms of the bargain, which could not be overridden by any attempted act on the part of the shareholders.

Mr. HOWARD said he would like to draw his lordship's attention to what would be the effect of the resolution. As his lordship saw, the preference shares amounted to £60,000, at 10 per cent. That was £6,000 a year. Instead of the £6,000 a year going to the preference shareholders, under the new resolution only £3,000 would go to them, and £3,000 to the ordinary shares. In other words, it would take £3,000 out of the preference shareholders' pockets, and put it into those of the ordinary shareholders. He submitted that the scheme for reducing the capital was not a *bonâ fide* scheme for the benefit of all the shareholders, but for the benefit of the ordinary shareholders at the expense of the preference shareholders. That was its real effect. It was quite true that the Company might be able to reduce its capital, but there were other ways in which that could be done without encroaching on the interests of the preference shareholders. His lordship would at once see that if preference shareholders were to be dealt with in this way the security of all preference shareholders would be very materially endangered.

Mr. RIGBY, Q.C., in opening the case for the defence, said that the question submitted to his lordship was really one of a bargain, and of the powers that had been reserved by the Company bearing upon it. What the Company was doing his lordship would understand could not be attacked under any illegality outside the powers which were contained in the Articles, or the terms upon which the preference shares were issued. The Company was originally formed for the purpose of purchasing a cable already existing and laid down between the Lizard and some place in Spain. A cable in those days cost a large sum of money. £125,000 he thought was the price paid for it, and it formed a most important part of the assets of the Company. A second cable was laid down—he would not say side by side, but generally in the same direction, and a third cable was purchased by the Company in the Mediterranean between Marseilles and Barcelona. Now, of those assets the original cable had gone. It was not a question admitting of anything like controversy. With the full knowledge and approval of the shareholders of the Company the Directors had abandoned that cable as useless. They had gone so far as to pick up what could be got at. Something like 150 miles of it had been picked up, and, according to the reports laid before the shareholders, what remained of the cable would not pay the cost of picking it up. The cable was gone, and therefore an important part of the capital of the Company, to the extent of pretty well £112,000, had gone with it, just as completely as if an earthquake had taken place, and the Company was *de facto* shorn of that important part of the assets. The others that remained were perishable property—very perishable, indeed—and they required for the purpose, not of replacing the original one—that was hopeless—but for the purpose of creating a fund for preserving the life of the existing ones, after the payment of the debenture debt and other expenses, to carry forward a large sum—and it must be done according to the terms of Articles of Association—to constitute a fund for the replacing of those old cables. Now, under the circumstances, there was a class of preference shareholders, created under the terms of the Articles of Association, entitled to a preference as regarded dividend, but to no preference whatever as regarded capital. The preference shareholders really came there and said, "We are in this favourable position, that we are, as it were, annuitants on the profits, and you have no right at all to take into consideration the fact that one half of our capital is actually gone. Although the Act of Parliament says you may, and although it was provided by the Articles that you might, you have no right to take into consideration the misfortune that has happened to us in common with the other shareholders of the Company that half our capital is lost." Now the clause under which they were going provided for the power to reduce capital—to cancel any lost capital or any of the capital unrepresented by available assets. There was no conflicting evidence on that subject at all. The value—which they had taken at £95,000 of that lost capital—had disappeared. There was no dispute as to the figures, as to its fair value, or, at any rate, a moderate value, of the capital that was actually gone, and under the Companies Act the Company had power to cancel any capital unrepresented by available assets—in other words, to cancel that £95,000. He quite agreed—and his lordship would not hear anything from him to the contrary—that if there had been in their bargain with the preference shareholders anything which prevented them from recognising the facts in the way in which the Legislature intended that they might recognise them—if they had bargained not to reduce the capital that was to say—they must stand by their bargain. But that was not the fact. One of the terms of the arrangement which the Directors entered into—or, rather, their predecessors—when the preference shares were issued—was that the capital might be reduced. They had to contemplate that losses might arise, and in that event preference shareholders had to take their share of the loss along with the others. It was rather suggested that this was a case where the ordinary shareholders used their voting power to the prejudice of the preference shareholders. He ventured to submit that that was not so at all. He had a report of the meetings at which the whole matter was discussed, with the number of voters and so on, and the number of preference shareholders who agreed to the proposal was almost as large as that of the ordinary shareholders. The numbers for the original resolution were as follows: 34 ordinary and 29 preference shareholders—these were by proxy—and 17 held up their hands whose holding (whether preference or ordinary) did not appear to be quite clear, and only five voted against the resolution. He merely mentioned that as a fact. He did not say that it would alter the powers in the least, but it showed at any rate that it was a question in which a large majority of the preference shareholders themselves were agreed, and that they approved of the plan that was to be adopted, and presumably, therefore, considered it to be to their interest. He agreed, however, that that would not affect the question from a legal point of view. The question really before them was this—Was it intended that those preference shareholders should have, whatever might be the vicissitudes of the Company, a fixed annual payment of £6,000 a year as a preferential charge upon the profits, or was it not? He would now call his lordship's attention to the Articles of Association from his (the speaker's) point of view. The clauses that were important had already been read, but he would like to offer a few observations upon them. Turning to page 6 of the Articles, to which has lordship's attention had already been directed, they found that Article 7 said: "The Directors may with the previous sanction of a special resolution of the Company increase its capital by the issue of new shares to such an aggregate amount with such preferential right to dividend" (that was what was exercised), "and such priority in the distribution of assets, or subject to such postponement of dividends, or in the distribution of assets as should in such special resolution be provided." Now, he would point out that by this Article, if it were for the benefit of the Company, the shareholders in general meeting if they were in a majority sufficient to pass a special resolution on their authority, could at any rate create capital over the heads of the preference shareholders. They could create pre-preference shares to any extent, and in that way could deprive the preference shareholders of what they thought their vested interests—their right to the annuity of £6,000. There was no such thing as a bargain with them that, under all circumstances, and throughout all time, they should have £6,000 a year. If it had been said that there should be paid to them £6,000 a year, under all circumstances, that would have been a different thing. But it was not so. They were in a position perfectly capable of being defined accurately by reference to the bargain entered into. So long as the capital stood as it did at the time when the preference shares were issued, the preference shareholders had an undoubted right to be paid at the rate of a fixed preferential dividend of 10 per cent. per annum on their shares—so long as the capital was unaffected in any way. That would have amounted, as his learned friend had said, to £6,000 a year in a concern represented by a capital of £60,000. But the capital might be altered in different ways. They might alter it to any extent by increasing it, and so they might postpone the payment of the £6,000 a year with perfect propriety. It might become a second, third, or fourth charge, and if the Company became unfortunate, or if they were engaged in a bad business, the £6,000 might disappear. He would not trouble his lordship with Clause 8, but Clause 9 provided that "all capital raised by the creation of new shares should be considered as part of the original capital, and should be subject to the same provisions in all respects." Therefore those preference shares were part of the original capital. There was nothing in the Articles to which his attention, or that of his lordship, had been called which modified that. If he turned to the resolution authorising the raising thereof, he certainly did find that there was one provision, and one only, which affected the preference capital—provision 3 of the special resolution—and which said the preference capital "shall be entitled to a fixed preferential dividend of 10 per cent. per annum, and if in any year the net profits of the Company shall not be sufficient to pay the whole, the balance shall be paid out of the profits of subsequent years." He agreed that that was an important alteration, giving the preference holders a better position as regarded dividend than the other shareholders, but it was the only alteration introduced by the special resolution, and except in that particular their capital was part of the original capital of the Company in all respects, and liable to all the incidents that attached to it as part of the original capital. One of those incidents was that the capital of the Company in certain contingencies sanctioned by Parliament might be reduced; that was one of the incidents that would arise with regard to a Company even if there were no clause in the Articles, and it might be brought in by a special resolution. But in Clause 10 it was expressly provided that "the Company may, by special resolution, from time to time reduce its capital, and alter the amount and denomination of its shares." His lordship would therefore see that taking that along with Clause 9 the Directors were entitled to read it:—"The Company may reduce its capital, including any capital that may be created with a preferential dividend" (that was according to Clause 9) because that incident, among others, applied), "and may alter the amount and denomination of the shares." It could only be done, of course, in accordance with the Act of Parliament, which clearly laid down the provisions which enabled a company to do it, and the cases in which it could be done. One of those cases had arisen in the present instance. There disappeared by a misfortune common to all partners interested in the concern an asset which was worth £95,000 when it was a good going cable, and the preference shareholders wished to introduce into the bargain made with them a term which was not only not there, but which was excluded by the terms of the Articles. The only advantage which they were to have was that 10 per cent. was to be paid on their capital, but in all other respects they were to be in position of the holders of the original capital. They had their votes. They exercised their right of voting solely by virtue of that clause, which put them on the footing of the original capitalists. Therefore the amount of power and authority to be given to them in the Company was defined by the actual bargain—the conditions of which

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were equally defined, to which each one must have subscribed when he took his shares, providing that "the capital shall be liable to reduction." How was it possible to exclude that from the terms of the bargain? Suppose they had put into the resolution "this is to be without prejudice to any other of the previous Articles," there could then be no doubt about it. But no one reading the Article could fail to see upon what terms the preference shareholders took their shares. The resolution itself did not allow anyone to determine for himself what position he would hold in the Company. He was obliged to go to the Articles, and there he found that his capital was in all respects part of the original capital of the Company, with the single exception that he was not to be paid with the others whatever their dividend might be, but he was to be entitled to a dividend upon his capital of 10 per cent., and he found written in the document which defined his rights and constituted the bargain between him and the Company—he found there written before his eyes the fact that the capital might be reduced. Now he (the learned counsel) would remind his lordship that in Clause 10 the capital did not mean the original capital, but it meant all the capital, for the time being, of the Company. If all the capital for the time being of the Company included preference and ordinary shares, they could not reduce one part. That would indeed be *ultra vires*. They must reduce it in proportion to the interests of the holders. It was a great misfortune to all of them, no doubt; but if their cable was still at work they would not have required the proposed reduction. But, *de facto*, the half of their assets had been swept away. The case that was contemplated by the Act of Parliament now arose. The half of their available assets was gone, and the policy of the Legislature was to bring the accounts of the Company in accordance with the facts—to recognise facts. Half of the capital having disappeared, all that the Company did was to recognise that fact. If it could have been made out that this was an arbitrary use of the power of a company, whereby the ordinary shareholders were taking in their own interest a step which was objected naturally to by the preference shareholders, there might have been more ground for examining into the finances of the Company, and so on, and asking whether it was fair. But, after all, by the terms of the constitution of a company, it was determined that a general meeting—by such a majority as the Legislature required for passing a resolution—should be the judges. He ventured to say that it could not be represented that this was a scheme on the part of the ordinary shareholders, where they were exercising a power which by the literal terms of the bargain was not vested in them—or where they were exercising a power not because a *bonâ fide* case of the kind contemplated by the Legislature had arisen, but for a culpable purpose. On the contrary, a case for the exercise of the power contemplated by the Legislature—namely, that there were not the available assets which represented the nominal capital of the Company—had arisen. Their loss had come upon them as a misfortune. In the action cited by his learned friend, Blisset *v.* Daniel, the case had not arisen. There was a nominal power to do a certain thing, and seeing that in the wideness and extent of that power was an opportunity for carrying out a scheme which they ought not to have carried out, and which the power was never intended to facilitate, they made use of the general power with the unjust intention of bringing about a state of things not contemplated. But here what they did was done when the actual state of things arose. Let them also suppose that in the case of Allhuisen *v.* Borries that it had been settled that on the death of Mr. Allhuisen the partnership might be dissolved if the parties thought fit, it would be idle for the parties to come forward and say when that event arose, "You cannot exercise it, because the exercise of that power will incidentally be injurious to the son." The answer would be clear. That was one of the terms of the bargain. The event had arisen upon which the power should be exercised. It must have been in the contemplation of the parties that the event so provided for would arise, and therefore what was intended by the partnership was brought about by the exercise of the power. When a case arose of the reduction of the capital of a company, the company might exercise its powers. In this case it had arisen, and they said, "Now we must exercise the power given to us by our bargain and by the Act of Parliament. We exercise that power, and it is not for you to say, 'Oh, but that will in an indirect manner have an evil influence upon the preference shareholders.'" That must have been contemplated. Whoever taking preference shares could have failed to see that, if the share capital were reduced—which was one of the things contemplated—his right to dividends on what remained of the capital would be to him less valuable than it was before? There was only one plaintiff here, but he would give that gentleman the benefit of the four others who voted with him. The five preference shareholders—he would assume that they were all preference shareholders, as it was not stated to the contrary—those five out of the thirty-four preference shareholders voted that they did not think that this would be a step for their advantage. That was all. Now, if there was a definite bargain that this would not be done, or, if they could find from any fair construction of the arrangement made that it would not be done, there would be an end to the question. But, on the contrary, there was an express bargain that it might be done, and when the case arose for the reduction of capital the preference shareholders were holders of capital on the same terms as the others. How could it then be said, "You are taking an unfair advantage of that power?" He quite agreed that the Court would look with very great anxiety to see that no injustice was done. But what was the actual constitution of those companies? The shareholders would have different views as to their own interests. If the preference shareholders wished to protect themselves against a possible reduction of capital in a case which might arise, they could have bargained either for a veto upon any such arrangement, or in some other way they might by the bargain have provided some means for protecting themselves against such reductions. But, on the contrary, they submitted to the terms that the Company should always have the power to reduce the capital, and now they came forward to repudiate those terms. He did not think there were cases which could illustrate the matter to advantage. His lordship had seen the way in which the question rested, and how the necessity in the first instance was forced upon the Board of Directors. The Board had not acted in any arbitrary manner. They had brought the whole matter fully before the shareholders' meetings, the reports of which he could go into. No doubt Mr. Bannatyne was perfectly right in saying, "I attended the meetings and voted against the resolutions." Mr. Bannatyne's action was taken expressly for the purpose of asserting what he believed to be his right. But when it was found that Mr. Bannatyne and others had agreed that the power of reduction in a proper case might be made, what right had that gentleman to repudiate that term of the bargain when the case had arisen, or because, he said, "in my opinion that will not be for the advantage of the other preference shareholders?" The other preference shareholders might well take a different opinion. It was quite open for the other preference shareholders to say "We do not at all agree with you." That, in fact, was what they had said by their votes—"we do not think it would be for our advantage not to accept the position as proposed." The advantage of the arrangement proposed would be that they would be entitled to a share in a company which would be a real dividend paying company from the present time. Part of the bargain was that they were to receive, he would not say a large sum per share—£2. 10s.—down, which was 25 per cent., he might say, of the value of their shares, with the prospect of an immediate dividend meantime. He could only say this, that it was by no means clear as a matter of commercial value that a nominal £10 share, which might at some future indefinite period be entitled to a certain interest, was better in value than a share of the nominal value of £5 with £2. 10s. paid down for arrears, and the prospect of immediate dividends. In order to establish the case at all, however, it must be shown that the vested right which the preference shareholders claimed was vested in them—not the right of judging as to their own interests, but the right independent of every one else—the independent members of their own class also, to say the thing could not be done. Not because it hurt their own interests—they might be the judges of that—but because there was something in the contract which prevented it from being done. If he were right in the view he took, so far from there being anything in the contract which would render it improper, when the case properly arose, to reduce the capital, there was a provision in express words that that case might be taken advantage of. At present they had only got so far as to pass the special resolution. That was the necessary preliminary. Their next step was to present a petition to the Court. They were obliged to get an order of the Court to its sanction. Everything would be done in accordance with the provisions of the Act of Parliament, under the direction of the Court of Chancery, and not otherwise, and unless they could find at the very threshold a clear provision that the power of reducing the capital could not be exercised—instead of which they found what they considered a clear provision that it might be—he submitted that the Court had no jurisdiction, and ought not to interfere in the case.

Mr. BEALE said there was very little to add. He, however, wished to deal with this point, that Mr. Marten in opening the case referred his lordship to the principle of the case Blisset *v.* Daniel. Now, if he (Mr. Beale) understood the case, it was one where the Court interfered when a power of this sort was exercised by people merely and solely for their own exclusive benefit. If that were so, the present was not such a case. They were not doing this merely and solely for their own benefit. They were doing it for the benefit of the Company to meet a misfortune that had befallen the Company. They were doing what any reasonable man of business did when he lost the assets of his original capital, reducing the amount of that capital, which the Legislature expressly empowered a company to do under the circumstances. It was suggested by the other side that it was putting the money of the preference shareholders into the pockets of the ordinary shareholders. But he ventured to say it was not doing anything of the sort. It was not the money of the preference shareholders that was touched. The capital had been lost. The preference, as well as the ordinary shareholders, had lost the capital, and the former could not look on the profits of the Company as their money until that capital was replaced. It was a scheme for the benefit of all—possibly a little disagreeable to the minority—but, nevertheless, a thing done in the way in which the Legislature said it should be done. Mr. Bannatyne said, in effect, "Instead of fulfilling the terms of the bargain to which I am entitled, they propose to reduce the capital." He answered that that gentleman was not so entitled. The bargain was that they might reduce the capital in certain circumstances, and that was what they were doing. Then, as his lordship knew, the policy of reducing capital was expressly introduced by the Legislature to meet the ordinary case raised. There was really no hardship in it. A bargain had been made under the original state of the capital of the Company, and, under its present state, what they proposed doing was only what might be expected to be done.

Mr. BUCKLEY said he appeared for Sir James Anderson, the Chairman of the Company, and the other Directors, who were joint defendants in the action. The arguments which had been addressed to his lordship from the other side had, he thought, in substance proceeded upon a hypothesis in favour of the plaintiff. He had not heard any arguments from his learned friend which would amount to a determination of the point in his favour, and what he conceived his lordship would have to determine was this—whether the special resolution which created the preference shares entitled the preference shareholders to receive for all time 10 per cent. upon the total amount which they paid upon their shares, or on such sum as might for the time being be their capital in the Company. Now, they must remember the nature of the subject with which they were dealing. It was the capital of a company incorporated under certain Acts of Parliament which contained in them a power to reduce its

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capital. It was a false supposition, therefore, to say that the amount of the capital was necessarily a fixed quantity. *Primâ facie* it was not a fixed quantity. It was something which was so much to-day, and which by a process of reduction might become something else to-morrow. Now, the whole of his learned friend's arguments proceeded on the hypothesis that it was a fixed quantity. His learned friend said: "There has been a fixed capital, upon which I am entitled for all time to 10 per cent. because I paid £10 for my shares." He (Mr. Buckley) denied that proposition. When Mr. Bannatyne paid £10 on his share he paid £10 as a subscription to a capital which was liable to be reduced, as might be seen from the terms of the contract. In the first place the resolution was founded upon Article 7 of the Articles of Association, and contained powers to do two things wholly different—one to give a preferential right to the dividends, and if there was not enough in one year to make it up out of the profits of subsequent years; and the other to give a priority in the distribution of the assets It was clear that they had used only the former of those powers. If that was so, so far as the capital subscribed on those shares was concerned, the matter was left to rest on Article 9, which provided that the capital should be considered as part of the original capital, because they did not find anything in the special resolutions which pointed to its being different from the original capital. That being so the capital subscribed upon the preference shares stood precisely on the same footing as the other capital, and was capable, therefore, of being reduced in common with the latter, and whatever the consequences of that reduction might be those consequences must fall equally on both. There was another way of looking at the question. His lordship knew very well that if the majority of the shareholders of the Company chose to pass resolutions winding up the Company, the assets would be distributed among the shareholders. It was not pretended that that would not be so. But in a reduction of capital his lordship would remember that the Act of Parliament provided for the satisfaction of all the debts of the creditors at that date in precisely the same way as if there were a winding up. The matter went to chambers. Every creditor was entitled to come in, and before the Court could make an order sanctioning the reduction of the capital it must be satisfied that every creditor at the date fixed had either been paid or that his claim had been provided for to the satisfaction of the Court. A reduction of capital, therefore, was in many—he would say in most respects—analogous to a winding up *pro tanto*. It was exactly the same as if a company starting with £100,000 wound itself up to the extent of £50,000; but until it could clear away its creditors it could not go on with the reduced capital. That was the nature of the scheme for a reduction of capital. Why should it not be competent to the shareholders to apply that machinery exactly in the same way as if there were a winding up? If there were a winding up in its place the loss of the capital would fall equally on all the shareholders, ordinary as well as preference. He submitted that the true view of the Act of Parliament in writing off capital, as they were entitled to by the Act of 1877, was to work the matter out in the same way as if there were a winding up of the Company. He submitted to the Court that the reduction of capital in this case was not only right, but was the only way in which it could be reduced. His learned friend's argument must go as far as this—that in a company of this kind, where a preferential right to dividend had been created, the Company had precluded itself from ever reducing capital at all; but he challenged his learned friend how it was to be done in any other way. Suppose they reduced the capital by writing off exclusively from the ordinary shares, leaving the preference untouched; in that respect his learned friend would say that would leave the preference shares unaltered. But he (Mr. Buckley) ventured to say it did not; because if six months after that the Company went into liquidation it would do so with preference shares of £10 and ordinary shares of £5, and the assets would have to be administered on that basis. No way could be pointed out in which capital could be reduced except by writing off £5 from every share equally, and he said that such a position was tantamount to saying that the Company could not reduce its capital at all. Article 10 contained an express power to reduce capital. The statutes referring to the Company conferred upon the Company, if it took power to do so, a right to reduce its capital. But his learned friend said, "You cannot reduce it because you have created a preference interest in respect of dividend." Was there any foundation or justification for such an argument as that? He found none at all. It appeared to him that his learned friend was endeavouring to construe the resolution creating preference shares—which was colourless on the point—as if it contained expressions saying that the resolution removed from the powers of the Company Article 10, which contained the powers to reduce the capital, and so impose upon the Company for all future time a veto upon ever reducing its capital. He submitted that the special resolution had no such effect as that contended for, and that the motion ought to be refused.

Mr. MARTEN, in reply, said that the arguments he had listened to had not in any way damaged the case which he had opened to his lordship. The first suggestion made by his learned friend, Mr. Rigby, was with reference to the number of shareholders voting. He did not think that there was any clear evidence what the number of votes was, so as to show any decided majority one way or the other. He submitted that the point on which he was arguing the matter was one quite independent of the numbers voting for or against. Was it not *ultra vires* to pass a special resolution, the effect of which would be to deprive the preference shareholders of a position of that for which they bargained? That was his argument, and if it was well founded it was immaterial what the number of shareholders who voted might be. He did not propose to go into that point. He apprehended there could be no question on this, that if what was being done was contrary to the bargain entered into it was *ultra vires*. Clearly Mr. Rigby agreed that the question really was whether the preference shareholders were entitled to have a fixed preference charge upon the profits. He submitted that there could be no question as to that. The resolution of 1874 expressly stated that those shares were entitled to a fixed preferential dividend of 10 per cent., and that in the event of there not being sufficient to make it up in any one year they were entitled to have it made up out of the profits of subsequent years, with interest in the meantime. That was endorsed on the certificates of shares when they went into the market. He submitted, therefore, that nothing could be clearer than the terms of that resolution. His friend, Mr. Rigby, said in the first place that several things might be done which would have the practical effect of vetoing that obligation—as, for example, that the Company could create pre-preference shares to any extent, and thus put the preference shareholders in a much less favourable position than they occupied by Article 7. His answer, of course, to that was this, that the additional capital could not be raised but in a proper case, and if it were raised, it would be for the advantage of all parties equally. There would be no advantage given to the ordinary shareholders, who would have a pre-preference capital equally with the preference shareholders. They were all familiar with the case in which everybody had to submit to the postponement of his claims for the purpose of raising further capital; but he submitted that Article 7 could not be made use of for that purpose, and write the preference shareholders out of their just claims. His friend had next referred to Article 9, which declared in plain terms that all additional shares created "shall be considered part of the original capital, and shall be subject to the same provisions in all respects as if it were part of the original capital." If the clause had stopped there, there might be a good deal to be said about that view, but it went on to add, "except so far as these Articles or the resolution authorising the raising thereof may otherwise direct." He ventured to say that that preserved intact the virtue of the resolution of 1874, and that no argument could be established by the Articles for making any difference in the contract from that which was in the plain terms of the resolution of 1874. The next argument of Mr. Rigby was this, "That the scheme is intended, not for the purpose of giving any present benefit to the ordinary shareholders at all, but it is a scheme which merely recognised in a formal manner the true facts of the case, and inasmuch as the capital to that extent has, in point of fact, according to the view taken by the Company and the Board of Directors, been really lost, we are now simply carrying into effect that which is a recognition of the actual facts of the case, and accordingly, therefore, the preference shareholders must not complain because the accident is a particular injustice to them." That was the argument put forward as he understood it. Now, the fallacy of that argument was plain. If the Company had proposed a nominal reduction of capital, the preference shareholders should still have the same amount of dividend. In that case it would be 20 per cent. on the reduced capital instead of 10 per cent. on the original capital. But there was no necessity for interfering with the preference shareholders' rights, and there was no necessity why they should resort to any reduction of capital. His lordship had only to look at the special report and circular—which was one of the first documents to which he drew his lordship's attention—and the Articles of Association and special resolution of 1874 to establish his case. That report pointed out particularly what was the nature of that which was proposed to be done? It showed that the result of writing off the nominal capital would be to give a reduced dividend to the preference shareholders, and to give a dividend at once to the ordinary shareholders. It was not, therefore, a fair way of looking at the matter to argue that it was merely a mercantile repudiation of a loss that had occurred, and that it was quite immaterial what the consequences might be to the various classes of shareholders. His argument was this, that if they proposed to take any step with regard to an alteration of the capital, that must be done with a view to the bargain already entered into being kept, and the ordinary shareholders could not at their own will put into their own pockets money which was reserved by special bargain for the preference shareholders. The Company had a plain course indicated to them, and indicated to them in the opinion of the eminent counsel (Sir Horace Davey) whose advice they took, by which after a time the capital would be restored and all the partners would have their rights again. Then it was said that it was part of the original bargain that the capital might be reduced. His answer to that was that it was no part of the original bargain that the shareholders who were preference shareholders were to be deprived of their preferential dividends. The capital might be reduced; but it must be done in accordance with the rights of the parties interested, and it could not possibly be alleged that the Company had a right to reduce the capital in such a way as would interfere with a special bargain they had made, any more than the Company when issuing debentures would have a right to say, "We will appropriate for the ordinary shareholders of the Company a portion of the money which was stipulated for by the debenture holders." The last argument of Mr. Rigby was that it was not clear that the preference shareholders would be injured. He (Mr. Marten) declined to go into an argument of that kind. There was not a tittle of evidence to show that it would not be to the injury of the preference shareholders if that course were adopted. But on the face of it it was absurd to suggest that the Company had a right to say that it had the power it sought to exercise. Mr. Rigby, in concluding, referred to the fact that there must be a petition presented to the Court for confirmation, but it would be inconvenient that the matters should be discussed on a petition, and of course now was the most convenient time, as it was the most expeditious way of disposing of the matter, and it would prevent the necessity of any petition being presented at all. His friend, Mr. Beale, in his argument addressed his lordship on this footing, that what was being done was not for the benefit of the ordinary shareholders but for the benefit of the shareholders at large. He (Mr. Marten) had dealt with that argument sufficiently in replying to the remarks of his learned friend Mr. Rigby. What was being done was specifically injurious to the preference shareholders, and was *ultra vires* in this sense, that the Company could not by any Act interfere with what was a

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bargain with the preference shareholders. It was said that the preference shareholders had lost the capital as much as the ordinary shareholders. That was not a true view of the case. The preference shareholders were in this position, that they could say, "We came into this concern, and paid our money on these terms." Therefore the Company could not deal with the matter on any such footing as that. With regard to Mr. Buckley's arguments he would speak very shortly. The first contention was that the Company might wind up if they thought fit, which would alter the whole of their rights. Nobody wanted to wind up the Company. He thought that was a sufficient answer to the argument. The Company was a good one, and there was no reason to apprehend such a contingency. Mr. Buckley also said that it was a winding-up of the Company *pro tanto*. The Company was a going concern, and there was no such suggestion. The Company was intending to go on. Mr. Buckley further said that his (Mr. Marten's) argument involved this, that the Company under no circumstances could reduce their capital, because this was the only way in which capital could be reduced. There was no proof whatever that this was the only scheme that could be adopted. He gave a suggestion that might secure to the preference shareholders all their rights. What was proposed to be done would be in manifest violation of the rights of the shareholders, and he submitted that he was entitled to the injunction asked.

The VICE-CHANCELLOR said the present question seemed to have come before the Court for the first time, at all events he had never before seen a case like this. The facts of the case were very simple. A company was formed subject to Articles of Association, which empowered it to increase its capital by the issue of new shares with a preferential dividend, and also to reduce its capital. That had reference to the position of the Company as between themselves and the outside world; but what had that to do with any bargain entered into between the Company and its shareholders? The arguments which had been urged on behalf of the defendants had no application to the case before him. The Company had borrowed money from the preference shareholders on certain terms expressed in the resolutions under which the shares were issued. That was a plain contract entered into by the Company with the holders of those shares—a contract which stated that the holders should be entitled to a "fixed preferential dividend of 10 per cent. per annum." There could be no doubt whatever that under the contract between the Company and the lenders of the money, the latter on paying their £10 per share became entitled to interest on their money at 10 per cent. It was true the Companies Act, 1877, gave power to a company to reduce its capital. There might be many cases in which it was desirable that the capital should be reduced; but at the same time the Act said that care must be taken to see that the creditors were not injured by the reduction. The shareholders of a company might settle between themselves what was to be done with regard to their own shares; but what inkling was there to be found in the Act of any power on the part of a company to depart at their will from any contract they had entered into? He had not heard it suggested that a company had such power. One argument addressed to him was that this Company could, without any consent on the part of their preference shareholders, wind themselves up, when the whole thing would go by the board, and that if they wanted more money they could give a preference over the present preference shares. The power of raising new capital was to be exercised for the benefit of the existing preference shareholders. That power was to be exercised not for the purpose of adding to their loss but to protect them from further loss. The real question was whether a company, having contracted to pay a dividend at a fixed rate, could by any contrivance, whether honest or fraudulent, say "We entirely neutralise the provisions we have made; and, more than that, these profits out of which we are to make up the 10 per cent. we shall pay to the ordinary shareholders." That would be the result of what was intended to be done by this Company. There was not a suspicion of dishonesty on the part of the Directors of the Company; he himself had no such notion. But there might be a case of other Directors whose motives were not so pure as those of the Directors of this Company; and if he authorised such a transaction as this he should be opening the door to the contrivances which the purlieus of the Stock Exchange were somewhat cognisant of, and be enabling persons to form fictitious joint stock companies. They might hold out a prospect to the preference shareholders, and as soon as they got the money by means of those preference shares they might resort to some expedient to cancel or reduce the amount of the capital, and so let in the ordinary shareholders, and let them take the same share as the preference shareholders would have been entitled to if they had been paid, for all time, as long as the thing would last, good years and bad years. It would be alarming to suppose that he could allow such a state of things. He could not go into motives, and he did not. He imputed no improper motives in this case, but in another case he would not be at liberty to look into the motives of the parties, if he found the thing done formally, as it was here. The consequence of allowing a company to do such a thing as this would be to raise the value of the ordinary shares from, perhaps, a farthing apiece to the same value as the preference shares. It would be a recipe for ousting the preference shareholders for the benefit of the ordinary shareholders. The resolution authorising the issue of the preference was literally within the terms of the Articles of Association; the amount of the new capital was mentioned there, the shares were mentioned there, and the contract was evidenced there. Some other mode than that proposed might be devised for effecting the reduction of capital, but, in his opinion, this 10 per cent. dividend was secured by the resolution and the certificates of the shares themselves mentioned in the contract. If he were to assent to the arguments of the defendants, it would be a wholesale authority to deprive persons of their rights fixed by contract. In his opinion, therefore, the plaintiff was entitled to the injunction asked for.

Mr. MARTEN: Then the order will be an injunction according to the terms of the notice of motion?

The VICE-CHANCELLOR: Yes.

Mr. MARTEN: The notice of motion asks for the costs of the motion. They will follow the result. We will say an injunction according to the terms of the notice of motion until trial or further order.

The VICE-CHANCELLOR: I make no order as to costs.

In reference to the above case, we are informed that an appeal has been granted, and will come on for hearing in a few days.

Callow v. Young.

Yesterday (Thursday), in the Chancery Division of the High Court of Justice, the case of Callow *v.* Young was heard before Mr. Justice Stirling.

The plaintiff, Mr. Douglas James Callow, who carries on business under the style of F. Young and Co., at 11, Clerkenwell-green, as a telegraph, telephone, and bell case manufacturer, sought to restrain the defendant, Mr. Frederick Young, from carrying on or being directly or indirectly concerned in the business of a telegraph, telephone, and bell case manufacturer under the name or style of F. Young and Co., or to carry on or assist in carrying on, or to receive the benefit of any such business within 100 miles of the Royal Exchange, in the City of London.

Mr. Warmington, Q.C., M.P., and Mr. J. F. Oswald (instructed by Mr. Herbert F. Oddy, of 58, Lombard-street), were counsel for the plaintiff. The defendant had entered an appearance, but was not represented by counsel.

Mr. WARMINGTON, in opening the case, said that prior to the 10th of November, 1883, the defendant carried on business in co-partnership with a Mr. Heaton, at 11, Clerkenwell-green, under the style of J. Young and Co., as telegraph, telephone, and bell case manufacturers. On that date the defendant (Young) assigned his interest to a Mr. James, who, with Mr. Heaton, continued to carry on business under the style of F. Young and Co. Upon the defendant Young retiring from that business he entered into an undertaking not to carry on a similar business, either in name or style, within 100 miles of the Royal Exchange. On the 11th of September, 1884, the present plaintiff acquired the interest of Messrs. Heaton and James, and he still continued to carry it on under the style of F. Young and Co., at 11, Clerkenwell-green. Amongst the original customers of the firm was the Consolidated Telephone Construction and Maintenance Company (Limited), of Farringdon-road, from whom important orders had been received for telephone cabinet work. The plaintiff now complained that shortly after he had acquired the business of Messrs. Heaton and James, the defendant took the lease of certain premises at 21, Lloyd's-row, Clerkenwell, and he there conducted a business precisely and in all respects similar to that which he had previously carried on, and which he had undertaken to Messrs. Heaton and James not to do. The plaintiff, as the assignee of their interest, of course complained, and sought the protection of the Court by asking that a perpetual injunction should be given restraining the defendant according to the terms of his covenant. The defendant did not carry on the business at Lloyd's-row in his own name, but put forward a man named Charles Carrington as proprietor. But Carrington was only a workman who had formerly been in the employ of the defendant, and who was paid £3 per week in the new business for allowing his name to be put forward as the proprietor. The defendant by this means, and also through the intervention of a Mr. George Alanson Mason, secured orders from the Consolidated Telephone Construction and Maintenance Company (Limited), who had been customers of the old business. This was, of course, detrimental to Mr. Callow, the plaintiff, and a source of considerable loss. It was believed by the plaintiff that this Mr. Mason was now engaged in carrying on a precisely similar business with the defendant as that which the defendant had been discovered to be carrying on with Carrington. The defendant, in certain affidavits which had been filed on his behalf, had said that he had only assisted Carrington as a friend, and that he had no personal interest in the business which was being carried on at Lloyd's-row; and also that Carrington had sold the business in April last to the American Telephone Company for £385. He (the learned counsel) was in a position to be able to call Carrington, who would say that that statement by the defendant was untrue, and that every shilling of the purchase money of the business in Lloyd's-row went into the defendant's pocket. Under all these circumstances he submitted that the plaintiff was entitled to restrain the defendant from doing anything of the kind again, and also to have an inquiry of the damages which he had sustained in consequence of the defendant's conduct in commencing another business in contravention of the covenant which he had entered into with Messrs. Heaton and James.

Mr. Charles Carrington said he had formerly been employed by the defendant at 11, Clerkenwell-green, and when that business was sold to Messrs. Heaton and James, the defendant again employed him at Lloyd's-row. An arrangement was entered into by which the business was to be conducted under his name, and he was to receive £3 per week. He had sworn an affidavit in which he said that the business was really his; but that was because he was induced to do so by the defendant. When the business was sold to the American Telephone Company for £385 the defendant wrote out a receipt and witness signed it without reading it. Witness never received a single shilling of the proceeds. The witness was severely questioned by the learned judge as to his swearing the affidavit and signing the receipt in the manner in which he detailed, but the statements were strictly adhered to.

Mrs. Carrington, wife of the last witness, corroborated as to the arrangement which was made between the defendant and her husband.

A witness named Parker said that he was employed at the business at

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Lloyd's row. The defendant Young acted as master of the business, and Carrington as foreman.

Mr. WARMINGTON said he had a mass of evidence, all pointing in the same direction. There were nearly fifty witnesses in Court; but he did not know whether the learned judge would require to hear them all.

The learned JUDGE said he thought that upon the evidence before him the plaintiff was entitled to a perpetual injunction.

Mr. WARMINGTON: And an inquiry of damages as well, my lord?

The learned JUDGE: Will you want that as well?

Mr. WARMINGTON: Yes, my lord. This is only the opening scene of these transactions.

A perpetual injunction was then granted, restraining the defendant his workmen, servants, or agents, from carrying on, or being interested in, the business of a telephone, telegraph, or bell case manufacturer, or any similar business, or the manufacture or sale of articles usually made or sold by makers or dealers in such business within 100 miles of the Royal Exchange, in the City of London. An inquiry of the damages sustained by the plaintiff by the defendant's previous breaches was also ordered to be instituted.

COMPANIES' MEETINGS.

Brazilian Submarine Telegraph Company (Limited).

The twenty-sixth ordinary general meeting of the shareholders in this Company was held yesterday at Winchester House, 50, Old Broad-street, under the presidency of the Right Hon. Viscount Monck.

The SECRETARY (Mr. Richard Collett) read the advertisement convening the meeting, and the minutes of the twenty-fifth ordinary general meeting, which were confirmed by the present meeting and signed by the Chairman as carried. The report of the Directors was taken as read.

The CHAIRMAN proposed the following resolution:—"That the report and accounts of the Directors to the 30th of June, 1886, now submitted, be approved and adopted, and that a dividend be now declared of 3s. per share, making, with the interim dividend already paid, a total dividend of 6 per cent., free of income tax, for the year ended the 30th June, 1886." He reminded them that the last time he addressed them he was compelled to say that the depression of trade which had prevailed for so many years, and which for a long time seemed to have spared the Company, had affected them in the way of receipts. The difference between the receipts for the quarter ended on the 30th of June this year and the 30th of June, 1885, amounted to a decrease of between £5,000 and £6,000; and he was bound to say that if it had not been for the improvement in the exchange as between this country and Brazil their loss would have been considerably larger. However, he was glad to say that they seemed to have touched bottom, because there had been a considerable increase in their receipts in the present half year, as far as they had gone, though they had reduced their tariff from 9s. to 7s. At the same time, they must not shut their eyes to the fact that though in many departments of trade they might notice an improvement, yet they could not assert positively that the depression which had so long prevailed had ceased to exist. They might, however, trust that they were turning the corner, and that their business, as well as other departments of trade, would be affected by the result. He told them at the last meeting that they were carrying on negotiations with a view to improving their position in Brazil. He asked them at that time not to call upon him to state explicitly what the nature of those negotiations was, or how far they had gone. The shareholders kindly acceded to his request, and he was sorry to say that he must still make a draft on their confidence and forbearance. It would not be for the interests of the Company that he should state at present the position of the negotiations, which, however, they hoped to bring to a successful issue. With reference to the accounts he did not think there was anything that called for observation. The general expenses were £198 less than those of the corresponding period of last year—a fact showing that, as far as possible, the Directors were consulting economy in the management of the Company's affairs. This reduction was also contemporaneous with a considerable expenditure on the renewal of houses and plant of different kinds at some of the stations.

The VICE-CHAIRMAN (Sir James Anderson) seconded the motion.

Mr. W. GRIFFITH asked what profit the Company were likely to make from their investment in the African Direct Telegraph Company. The balance-sheet, though it spoke creditably for the efforts made by the Directors, was not one which, in his opinion, gave the shareholders much encouragement for the future; and he found from official sources that, notwithstanding the great efforts of the Brazilian Government to foster private enterprise, they had had a woeful falling off in trade, and deficits for the last ten years. Though there did not seem much hope at present, it was possible that they might have something beneficial from their large investment in the Company mentioned.

The CHAIRMAN, in reply, stated that the African Direct Company's cables had only just been opened, and it would be very imprudent therefore for him to pronounce either for or against a very great traffic on that cable. Moreover, he was informed that that was just the time of the year when European people were away for their holidays, and when trade was more or less suspended. They hoped, however, that the cable might be made profitable, and he had no doubt that it would after a while.

The motion was then carried unanimously.

On the motion of the CHAIRMAN, seconded by the Hon. W. ST. JOHN BRODRICK, M.P., Dr. Taylor, who, the Chairman stated, represented the Company in Brazil, was re-elected to his seat at the Board; as was also Mr. Frederick Youle, on the motion of the CHAIRMAN, seconded by Mr. HENRY DANIEL GOOCH.

Mr. ANDERSON next proposed and Mr. C. S. HAWKES seconded the re-election for the ensuing year of the auditors, Mr. Henry Dever and Mr. John Gane.

The resolution was carried unanimously.

On the motion of Mr. HAWKES, seconded by Mr. GEORGE ANDREWS, a vote of thanks was passed to the Chairman and Directors.

The CHAIRMAN, in reply, said that the Directors were exceedingly obliged to the shareholders for the kind way in which they had treated them that day, and the confidence which they had always shown to them.

The proceedings then terminated.

Western Union Telegraph Company.

At the annual meeting of the Western Union Telegraph Company President Green submitted his report for the year ended June 30th, which shows the following results, contrasted with two previous years:—

	1883-4.	1884-5.	1885 6.
Revenue for the year	$19,632,940	$17,706,834	$16,298,659
EXPENSES—			
Operating and general expenses	$9,278,761	$8,544,554	$8,510,658
Rentals of leased lines	1,842,090	1,822,543	1.892,347
Maintenance and reconstruction	1,350,448	1,146,871	1,273,125
Taxes	301,077	301,723	499,592
Equipment of offices and wires	249,528	190,210	203,061
Total expenses	$13,022,504	$12,005,910	$12,378,783
Profits	$6,610,436	$5,700,925	$3,919,856
DISBURSEMENTS—			
For dividends	$5,599,179	$4,999,325	$3,399,573
For interest on bonds	472,350	495,072	494 461
For sinking funds	39,991	39,992	39,991
Total disbursements	$6,111,520	$5,534,389	$3,934,025
Balance of profits	$498,916	$166,536	- $14,169
Surplus July 1 (beginning of year)	$3,658,553	$4,157,469	$4,324,004
Balance of profits for year	498,916	166,535	- 14,169
Total nominal surplus June 30 (end of year)	$4,157,469	$4,324,004	$4,309,835

The following table exhibits the mileage of lines operated, number of offices, number of messages sent, receipts and profits, for the past four years:—

Year.	Miles of Poles & Cables.	Miles of Wire.	Offices. No.	Messages. No.	Receipts. $	Profits. $
1882-3	144,294	432,726	12,917	41,181,177	19,454,902	7,660,350
1883-4	145,037	450,571	13,761	42,076,226	19,632,939	6,610,435
1884-5	147,500	462,283	14,184	42,096,583	17,706,833	5,700,924
1885-6	151,832	489,607	15,142	43,289,807	16,298,638	3,919,855

The changes made in the directory were Austin Corbin, Henry B. Hyde, and John G. Moore, in the places of Harrison Durkee, Hugh J. Jewett, and Frank Work.

The Pilsen-Joel and General Electric Light Company (Limited).

An extraordinary general meeting of the shareholders of this Company was held on Tuesday at the City Terminus Hotel, Cannon-street, E.C., Sir Rawson W. Rawson, K.C.M.G., C.B., in the chair.

Mr. W. H. TRENTHAM (the secretary) read the notice convening the meeting, which stated that the meeting was called for the purpose of submitting a resolution having for its effect the reduction of the capital of the Company.

The CHAIRMAN said: Gentlemen, I hope it will not be necessary to detain you long to-day. Most of you will understand the object of our meeting, and to me it is a satisfaction at last to be able to present myself, and to offer to you an expectation of this property yielding a return to its shareholders. Hitherto my position here has not been either an acceptable one to myself or a very welcome one to you; but we fell upon hard lines at the commencement of our career. We have, however, persevered patiently, and, we hope, with a single view to the interest of our contributors; and we believe now that we see our way towards yielding a return to our shareholders — a modest one it must ever be whilst electric lighting, and lighting by arc lamps especially, is so little sought after by the public. But we have held ourselves firm during the last three years of difficulty and trial. We have maintained and established the excellence of our arc light, and whatever we have attempted of late has been carried out successfully, and, we hope to show, at a profit. And now the time has come when we may adopt the step which was referred to in our report of last year, but which we did not feel ourselves justified in then carrying out, whilst our prospects were still uncertain. "The point may present itself to shareholders that a further amount should be written off the Company's capital as lost, but although this subject has engaged the Directors' attention they have not considered any advantage would accrue from taking the step at present." Until we saw clearly the prospect of making a dividend upon our capital there was no advantage in reducing the nominal value of our concern, and incur the legal expense necessary to authorise us to reduce our capital. We do now see our way, and therefore we come to you to authorise that reduction of our capital, which by law must be effected before we can make a dividend. You are aware that in the last report the balance brought down against our capital was £22,878. Now, until that £22,878 has been recovered out of profits, we should not have been justified in making a dividend unless we reduce our nominal capital. It will not reduce the value of our property, because if we can increase our profits we shall be able to yield a larger dividend upon a smaller capital. It comes to be really as broad as it is long. We have gone through a time of storm; we

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have had our sails torn and our rigging damaged—with all the other companies—we have had a time of difficulty; but we now hope to get out of it, and we believe that by throwing our dead weight overboard and by trimming our ship we shall float into smooth water, and we look forward to a favourable breeze, which will enable us to make some return to our shareholders. We propose to wipe off that £22,878 of the balance. You will see that it is actually proposed to reduce the capital by £28,000; that is a deduction from the nominal value of our patents, which, of course, has been reduced to a certain extent by the lapse of time, and more particularly our patent for incandescent lamps, which never possessed a very high value, and which at the present time may be taken at a very low rate. This will make a reduction of our capital to the extent of writing off what is unrepresented by available assets, for if they were brought into the market at the present time they would certainly not yield even the sum at which we at present state them, and we believe that the steps we are now proposing will place our concern on a sound basis, and that we shall be able to call you together, possibly in a very short time, as soon as the Court has sanctioned this proceeding, with a favourable report for the last year. I therefore beg to move the resolution that has been read:—"If an order of the Court be obtained for confirming this resolution, the capital of the Company be reduced by cancelling the sum of one pound per share on the twenty-eight thousand shares of the Company of three pounds each, with two pounds five shillings called up thereon, and the sum of one pound fifteen shillings per share on the one hundred fully paid up shares of four pounds each, as being capital which has been lost or is unrepresented by available assets, and that the Memorandum of Association of the Company be modified so as to carry into effect this resolution."

Major HORACE W. SCRIVEN seconded the resolution.

Mr. KING: I think before you ask us to support that resolution you ought to supply us with a balance-sheet and revenue account of last year's working. You are asking us to write off £28,000, and we wrote off £28,000 last year. Why should we write off £28,000 in the dark? Surely you can supply a profit and loss account. Last year you stated that:—"The Directors feel satisfied that in the new premises the profit rentals from installations, royalties from licenses, and other receipts, may be confidently expected to more than cover all the general charges of the Company, including rent of factory, staff, directors' and auditors' fees, &c., and they look to the increasing development of electric lighting as a means of improving the value of the capital invested in the Company." That report is dated November 7, 1885; we are now in November, 1886, and the shareholders will naturally look to you for some information as to whether those sanguine estimates have been realised, and if so, why should they go on writing off £28,000 from their capital?

The CHAIRMAN: But we did not write off £28,000 last year. The statement produced to that meeting left a balance against us of £22,800.

Major SCRIVEN: We are not proposing to write off any further loss; it is the loss inserted in last year's balance-sheet. We were £22,000 to the bad last year; but since then we have more than paid all expenses.

Mr. KING: Then, consider my observations unsaid.

Major SCRIVEN: Our scheme was in lieu of winding up a year ago. We were all agreed that to go on making calls on the shareholders and wasting the money would be a mistake; but we recognise the possibility of living in a quiet way in the hope that our patents may be of value some day. If we had wound up, our patents would have sold for nothing; but by going on as we have we hope, as the Chairman has said, to be able to make you a small dividend. We believe that what was a failure has been turned into a success, and we now only propose to write off the loss that was incurred up to last year. We propose to write off £28,000 instead of £22,000, so that our shares may stand at even figures.

Mr. G. L. WHATELY: The other writing off of £1 a share was when the vendors' shares were cut off. It is now proposed to cut off a further £1.

Major SCRIVEN: You will understand that at the last meeting the sum had already been lost. If we do not write off the losses any little money we may make must be written off against them before we can pay a dividend.

Mr. KING: Do I understand you to say that we have made a profit last year?

Major SCRIVEN: We have more than covered our expenses. We have done quite as well as we expected.

Mr. FYFE: You may also say that the money said to be lost last year was merely through the manner of taking the stock.

Major SCRIVEN: A great deal of loss was incurred in selling the stock.

Mr. FYFE: In reducing the capital now you say there is a prospect of paying a dividend soon.

Major SCRIVEN: I am afraid it will be a very small one.

Mr. FYFE: Possibly the smaller the better for the good health of the Company. If we pay away the capital we have now, and have to make another call of 15s., it would not be agreeable to the shareholders.

Major SCRIVEN: I should say that would be a step which would justify great complaint on the part of the shareholders, and possibly would result in the removal of this Board.

Mr. FYFE: Therefore you must be very careful what you do.

Major SCRIVEN: Perhaps you had better wait until you have our proposal before you.

Mr. FYFE: There was no reason why the balance-sheet should not be placed before us. It has been made up for some time, and it would enable the shareholders to judge whether it is wise and prudent to make this reduction. I think this should be left to the Directors. This reduction has nothing to do with the balance-sheet which has yet to be presented.

Major SCRIVEN: Well, you are able to judge, because you are in possession of the facts.

Mr. WHATELY: If you issue a balance-sheet, exhibiting a profit—that is a profit declared—you must write it off before you reduce the capital; but as it is you can reduce the capital at once.

Mr. FYFE: I think even that would be better for the Company.

Mr. WHATELY: It is after all a pure question of discretion. Any shareholder can capitalise his small dividend if he chooses.

Mr. FYFE: At the last meeting I objected to the gloomy view put before the shareholders, and I then said that you could not have lost £22,000 in working.

Major SCRIVEN: It was not actually in working. It was a loss in selling off machinery that we did not require.

Mr. FYFE: Even then I say you did not lose so much.

Major SCRIVEN: It is not there.

Mr. FYFE: It is if you take the stock properly.

Major SCRIVEN: Of course, you can take the stock on any principle you like.

Mr. FYFE: Either my stock-taking of the previous year was utterly dishonest or there has been a tremendous waste since.

Major SCRIVEN: It seems to me you are discussing last year's balance-sheet, which was fully discussed and threshed out a year ago.

A SHAREHOLDER: When this reduction is made, will the shares be treated as fully paid up?

The CHAIRMAN: No; it does not alter the condition of the shares at all, except by a reduction of the nominal capital. It still leaves a liability of 15s.; but our object is to avoid the necessity of anything of the kind. We do not intend to make another call.

Mr. FYFE: Could we not write off 5s. from the present capital, and 15s. from the capital, and make them fully paid shares?

Mr. WHATELY: You could not do that without giving notice to every creditor, and it would take you a twelvemonth to get it through. To get rid of an uncalled amount on shares is a very elaborate process.

Mr. FYFE: But you can pay your creditors.

Mr. WHATELY: You still have to go through the Court in the same way. You have to satisfy the Court. You can do that afterwards. If the shareholders express their view there is no reason, I think, why the Board should dissent from it.

After some further discussion of a desultory character between Mr. FYFE and Major SCRIVEN,

The CHAIRMAN interposed: I think our members will trust their Directors for not depreciating the value of their property as Mr. Fyfe has supposed. We do not want to make ourselves paupers. On the contrary, in the revaluation of the stock and plant we have taken the lowest terms. There is no loss in the matter necessarily. If we can sell at a better price than the stock stands at in our books, so much the better for our proprietors; but it would not be wholesome for the Company that the stock should stand in our books at a price which we do not expect to realise. We could not pay a dividend after writing off only five shillings a share. We must write off ascertained losses before we declare a dividend.

Mr. FYFE: Would the shareholders not rather get rid of the liability on their shares, and defer the payment of a dividend?

Major SCRIVEN: You can do nothing at this meeting but vote yes or no to the proposition that is put before you.

The resolution was then put and carried *nem. dis.*

A SHAREHOLDER: I really think that our shares now ought to appear as fully paid up.

Major SCRIVEN: There is no reason why it should not be done. The reason why it was not done before was that we should have the capital to call if better times came for electricity; but we should not make any calls without consulting you. If there is a better Electric Lighting Act passed, and there is a prospect that by calling up a little money we should much improve our position, we should, as matters stand, be able to do it.

The meeting then closed.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. NOV. 3.		BUSINESS DONE WEEK ENDING NOV. 3. Highest.		Lowest.	
Anglo-American	38,	39		40½		37½
Do. Preferred	60½,	61½		62½		59½
Do. Deferred	16,	17		17½		15½
Brazilian Submarine	10⅞,	11½		11½		10⅞
Cuba	11½,	11⅞		—		—
Do. Preference	18,	19		—		—
Direct Spanish	1½,	2		—		—
Do. Preference	8½,	9½		—		—
Direct United States Cable	9½,	9½		9⅝		9½
Eastern Telegraph	10⅜,	10⅝		10⅞		10 7-16
Do. 6 per Cent. Preference	14½,	14⅞		14⅝		14⅝
Do. 5 per Cent. Debentures, 1899	105,	108		—		—
Eastern Extension	10⅞,	11⅛		11½		10⅝
German Union	9½,	9¾		9½		—
Globe Telegraph and Trust	5⅞,	6½		6½		5 15-16
Do. Preference	12⅜,	12⅝		12⅝		12⅜
Great Northern	13½,	13⅝		13 9-16		13 5-16
Indo-European	34½,	35½		—		—
Reuter's	7½,	7⅝		—		—
Submarine	195,	205		200		197½
West India and Panama	⅝,	¾		—		—
Do. 1st Preference	8⅞,	9½		9		8 11-16
Western Brazilian	6⅜,	6⅝		6⅝		—
Western Union 7 per Cent. 1st Mortgage	115,	120		—		—
Do. 6 per Cent. Sterling Bonds	101,	103		—		—

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TELEPHONES.

COMPANIES.	CLOSING PRICES. NOV. 3.		BUSINESS DONE WEEK ENDING NOV. 3. Highest.		Lowest.	
Consolid. Telephone and Maintenance..	13-16	15-16	.....	—	.....	—
Oriental	3-16	5-16	.....	—	.....	—
United Telephone	14⅜	14⅝	.....	14⅝	.....	14⅜

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)..	2½	3	.....	2 9-16	.....	—
Do. (fully paid)	4½	5	.....	4½	.....	—
Swan.....	1⅜	1⅝	.....	1⅜	.....	—
Maxim Weston	¼	⅜	.....	—	.....	—

MISCELLANEOUS.

Telegraph Construction	39	40	.....	40	.....	39½
India Rubber, Gutta Percha, and Telegraph Works	24½	25½	.....	25½	.....	21⅜

TRAFFIC RECEIPTS FOR OCTOBER, 1886

COMPANIES.	Oct., 1886.	Oct., 1885.	Increase.	Decrease
Cuba Submarine	2,400	2,156	244	—
Direct Spanish Telegraph ..	2,013	1,756	257	—
Eastern Extension	37,185	43,986	—	6,801
Eastern Telegraph	49,374	56,994	—	7,620
Great Northern	22,240	—	—	—
West Coast of America.....	4,285	—	—	—

King, Mendham and Co.,

Western Electrical Works, Bristol.

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(LIMITED).

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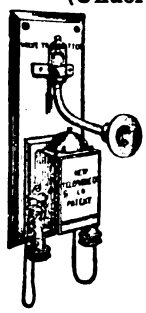

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The Company will give a formal guarantee to any purchaser requiring the same against any claims which may be made by trade rivals for alleged infringements.

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